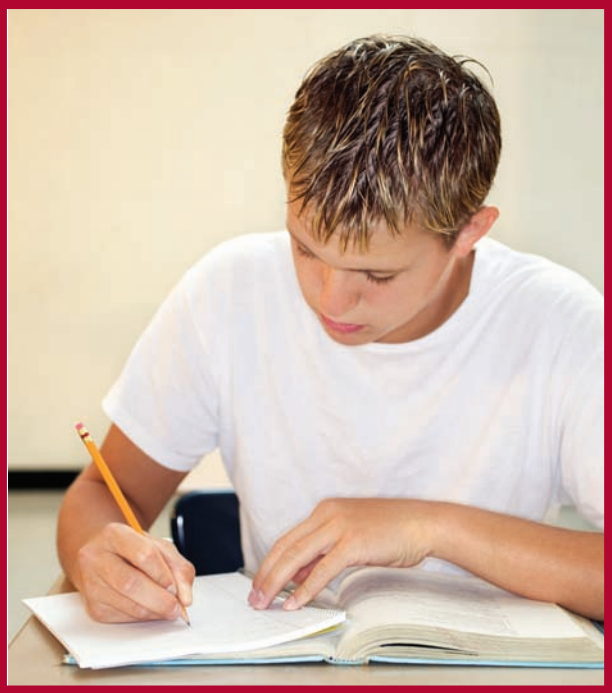
GRADE

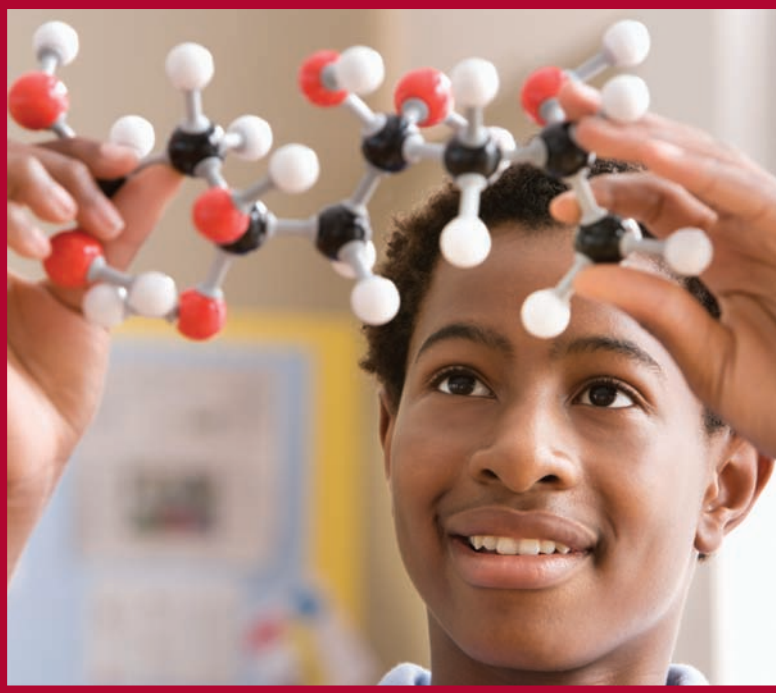
10

TAKS STUDY GUIDE

Texas Assessment of Knowledge and Skills

Science





A Student and Family Guide to Grade 10 Science

TAKS STUDY GUIDE

Texas Assessment of Knowledge and Skills

Grade 10

Science

A Student and Family Guide

Dear Student and Parent:

The Texas Assessment of Knowledge and Skills (TAKS) is a comprehensive testing program for public school students in grades 3–11. TAKS replaces the Texas Assessment of Academic Skills (TAAS) and is designed to measure to what extent a student has learned, understood, and is able to apply the important concepts and skills expected at each tested grade level. In addition, the test can provide valuable feedback to students, parents, and schools about student progress from grade to grade.

Students are tested in mathematics in grades 3–11; reading in grades 3–9; writing in grades 4 and 7; English language arts in grades 10 and 11; science in grades 5, 8, 10, and 11; and social studies in grades 8, 10, and 11. Every TAKS test is directly linked to the Texas Essential Knowledge and Skills (TEKS) curriculum. The TEKS is the state-mandated curriculum for Texas public school students. Essential knowledge and skills taught at each grade build upon the material learned in previous grades. By developing the academic skills specified in the TEKS, students can build a strong foundation for future success.

The Texas Education Agency has developed this study guide to help students strengthen the TEKS-based skills that are taught in class and tested on TAKS. The guide is designed for students to use on their own or for students and families to work through together. Concepts are presented in a variety of ways that will help students review the information and skills they need to be successful on the TAKS. Every guide includes explanations, practice questions, detailed answer keys, and student activities. At the end of this study guide is an evaluation form for you to complete and mail back when you have finished the guide. Your comments will help us improve future versions of this guide.

There are a number of resources available for students and families who would like more information about the TAKS testing program. Information booklets are available for every TAKS subject and grade. Brochures are also available that explain the Student Success Initiative promotion requirements and the new graduation requirements for eleventh-grade students. To obtain copies of these resources or to learn more about the testing program, please contact your school or visit the Texas Education Agency website at www.tea.state.tx.us.

Texas is proud of the progress our students have made as they strive to reach their academic goals. We hope the study guides will help foster student learning, growth, and success in all of the TAKS subject areas.

Sincerely,

Lisa Chandler
Director of Student Assessment
Texas Education Agency

Contents

Science

Introduction 5

Objective 1: The Nature of Science

Skill Review 10

Practice Questions 20

Objective 2: The Organization of Living Systems

Skill Review 24

Practice Questions 36

Objective 3: The Interdependence of Organisms and the Environment

Skill Review 40

Practice Questions 46

Objective 4: The Structures and Properties of Matter

Skill Review 50

Practice Questions 63

Objective 5: Motion, Forces, and Energy

Skill Review 66

Practice Questions 81

Science Cluster Practice Questions

Cluster 1 84

Cluster 2 86

Science Activity

The Floating Rubber Band: A Scientific Trick 88

Science Answer Key 93

SCIENCE

How is the Science Study Guide organized?

Five objectives are tested on the Grade 10 science TAKS test. This study guide is therefore organized into five main parts, one for each objective.

- Objective 1: The Nature of Science
- Objective 2: The Organization of Living Systems
- Objective 3: The Interdependence of Organisms and the Environment
- Objective 4: The Structures and Properties of Matter
- Objective 5: Motion, Forces, and Energy

For each objective there is a review and a set of practice questions. Start by reading the review for each objective. After you read the review, you can test your knowledge of the objective by trying the practice questions.

Will this study guide tell me everything I need to know about science?

No, but it's a great place to review what you've learned in school. This study guide explains some, but not all, of the science ideas that you need to know and understand. You can also increase your science knowledge by studying:

- Science books from your school or library
- Notes from your science classes
- Science tests, quizzes, and activity sheets
- Laboratory reports and notes from field investigations

What kinds of practice questions are in the Science Study Guide?

The science study guide contains questions similar to those found on the Grade 10 science TAKS test. There are three types of questions in the science study guide.

- **Multiple-Choice Questions:** Most of the practice questions are multiple-choice items with four answer choices. Many of these questions follow a short passage, a chart, a diagram, or a combination of these. Read each passage carefully. If there is a chart or diagram, study it. Passages, charts, and diagrams usually contain details and other information that will help you answer the question. Then read the question carefully and consider what you are being asked. Read **each** answer choice before you choose the **best** answer.

  It's always a good idea to reread the question after you have thought about each answer choice.

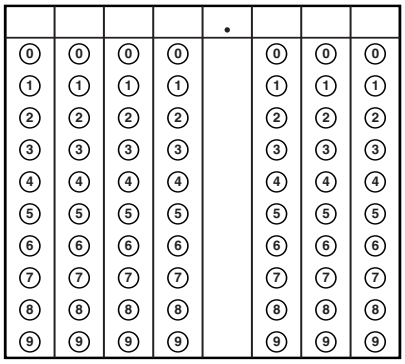
- **Griddable Questions:** Some questions use an eight-column answer grid like the ones used on the Grade 10 mathematics TAKS test. Griddable questions ask you to measure something or use math to solve a science problem. You will see an example of a griddable question on page 63.

- **Cluster Questions:** Some multiple-choice questions are grouped together in clusters. Each cluster begins with a stimulus that may include a passage, a diagram, a chart, or a combination of these. The information in the stimulus will help you focus on the cluster questions.

The stimulus is followed by two to five multiple-choice questions. The cluster questions usually test several different science objectives, but they are all related to the stimulus. To answer the cluster questions, you will need to use information from the stimulus, as well as your own knowledge of science, so read and study the stimulus carefully before you answer the cluster questions. Then think about what you already know from your study of science. You will see examples of science clusters on pages 84–87.

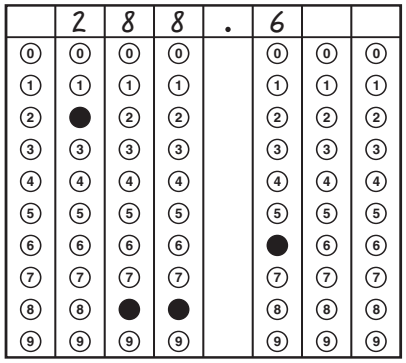
How do I use an answer grid?

The answer grid contains four columns of numerals followed by a fixed decimal point and three additional columns of numerals. Your answer will always be limited to a number from 0 to 9,999.999.



This is the grid found on the actual test.

Let's say you are asked to calculate the force needed to accelerate an object to a velocity of 1.8 meters per second. If your answer is 288.6 newtons, you should write the digit 2 at the top of the hundreds column, an 8 in the tens column, an 8 in the ones column, and a 6 in the tenths column. Be careful to record the digits in the column with the correct place value with respect to the decimal point. Then fill in the bubbles that correspond to your answer. Find the correct bubbles and darken the circles. Check to make sure that you bubbled in the same number that you wrote at the top of each column.



Extra zeros before or after the answer will not affect your score.

How will I know whether I answered the practice questions correctly?

The answers to the practice questions are in an answer key at the back of this book (page 93). For most questions, the answer key explains why each answer choice is correct or incorrect. After you answer the practice questions, you can check your answers to see how you did. If you chose the wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

If you still do not understand the correct answer, ask a friend, family member, or teacher for help. When you choose the correct answer, it is still a good idea to read the answer explanation. It may help you better understand why the answer is correct.

Is there anything else in the Science Study Guide?

Yes! A formula chart is provided on page 8 of this study guide. It is identical to the formula chart that is provided to you when you take the Grade 10 science TAKS test. You will need the formula chart to answer some of the practice questions. The good news is that you don't have to memorize the formulas, constants, and conversions. However, you do need to know how to use them to solve science problems. Remember, knowing which formula to use is just as important as knowing how to use it. You'll learn more about formulas, constants, and conversions in the review for Objectives 4 and 5. The formula chart also contains a 20-centimeter ruler.

A periodic table of the elements is provided on page 9. An identical periodic table is provided when you take the Grade 10 science TAKS test. You will need information from the periodic table to answer some of the practice questions. You'll learn more about the periodic table in the review for Objective 4.

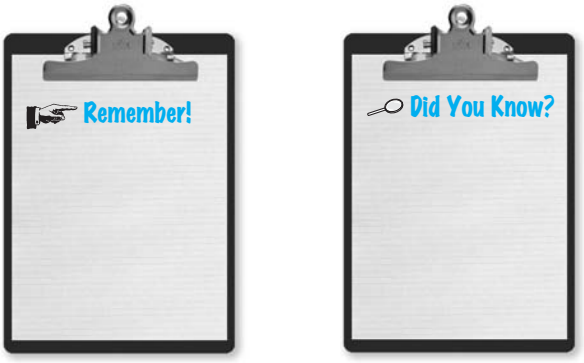
In addition to the materials on pages 8 and 9, a tear-out copy of the formula chart and the periodic table is provided at the back of this study guide.

There is a science activity called "The Floating Rubber Band: A Scientific Trick" on page 88. You can do this activity at home. It will help you practice and strengthen some of the science skills that you'll review in Objective 4 (The Structures and Properties of Matter). The review for Objective 4 begins on page 50. After you complete the activity, you can compare your results with the sample results on page 103.

Many of the review pages contain clipboards. The clipboards contain tips, helpful information, important facts, and interesting details.

Remember! clipboards contain information that you have probably learned before. They are reminders to help refresh your memory.

Did You Know? clipboards contain fun science facts that are probably not familiar to you.



How do I use this study guide?

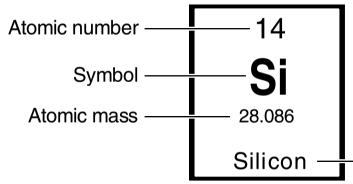
Carefully read the review section. If you do not understand something, ask for help. Then answer the practice questions. Use the answer key at the back of this study guide to check your answers. It is a good idea to read all five reviews and answer all the practice questions even if you passed some of these objectives. Study at a pace that is comfortable for you.
The Science Study Guide contains a lot of information. If you plan to read all the reviews and answer all the practice questions, you may want to allow yourself several weeks.

FORMULA CHART
for Grades 10–11 Science Assessment

Density $=\frac{\text{mass}}{\text{volume}}$	$D=\frac{m}{v}$
$\begin{pmatrix}\text{heat gained or}\\ \text{lost by water}\end{pmatrix}=\begin{pmatrix}\text{mass}\end{pmatrix}\begin{pmatrix}\text{change in}\\ \text{temperature}\end{pmatrix}\begin{pmatrix}\text{specific}\\ \text{heat}\end{pmatrix}$	$Q=(m)(\Delta T)(C_p)$
Speed $=\frac{\text{distance}}{\text{time}}$	$v=\frac{d}{t}$
Acceleration $=\frac{\text{final velocity – initial velocity}}{\text{change in time}}$	$a=\frac{v_f-v_i}{\Delta t}$
Momentum = mass × velocity	$p=mv$
Force = mass × acceleration	$F=ma$
Work = force × distance	$W=Fd$
Power $=\frac{\text{work}}{\text{time}}$	$P=\frac{W}{t}$
% efficiency $=\frac{\text{work output}}{\text{work input}}\times 100$	$\%=\frac{W_O}{W_I}\times 100$
Kinetic energy $=\frac{1}{2}$(mass × velocity^2)	$KE=\frac{mv^2}{2}$
Gravitational potential energy = mass × acceleration due to gravity × height	$GPE=mgh$
Energy = mass × (speed of light)^2	$E=mc^2$
Velocity of a wave = frequency × wavelength	$v=f\lambda$
Current $=\frac{\text{voltage}}{\text{resistance}}$	$I=\frac{V}{R}$
Electrical power = voltage × current	$P=VI$
Electrical energy = power × time	$E=Pt$

Constants/Conversions		
g = acceleration due to gravity = 9.8 m/s^2		
c = speed of light = 3×10^8 m/s		
speed of sound = 343 m/s at 20°C		
1 cm^3 = 1 mL		
1 wave/second = 1 hertz (Hz)		
1 calorie (cal) = 4.18 joules		
1000 calories (cal) = 1 Calorie (Cal) = 1 kilocalorie (kcal)		
newton (N) = kgm/s^2		
joule (J) = Nm		
watt (W) = J/s = Nm/s		
volt (V)	ampere (A)	ohm (Ω)

Periodic Table of the Elements



Group	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.008 Hydrogen																	2 He 4.0026 Helium
2	3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.179 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminum	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.066 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.08 Calcium	21 Sc 44.956 Scandium	22 Ti 47.88 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.847 Iron	27 Co 58.933 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc (98) Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.906 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.868 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.763 Antimony	52 Te 127.60 Tellurium	53 I 126.904 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.905 Cesium	56 Ba 137.33 Barium	57 La 138.906 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.383 Thallium	82 Pb 207.2 Lead	83 Bi 208.980 Bismuth	84 Po (209) Polonium	85 At (210) Astatine	86 Rn (222) Radon
7	87 Fr (223) Francium	88 Ra 226.025 Radium	89 Ac 227.028 Actinium	104 Rf (261) Rutherfordium	105 Db (262) Dubnium	106 Sg (263) Seaborgium	107 Bh (262) Bohrium	108 Hs (265) Hassium	109 Mt (266) Meitnerium	110 (269)								

Mass numbers in parentheses are those of the most stable or most common isotope.

Lanthanide Series	58 Ce 140.12 Cerium	59 Pr 140.908 Praseodymium	60 Nd 144.24 Neodymium	61 Pm (145) Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.925 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.930 Holmium	68 Er 167.26 Erbium	69 Tm 168.934 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium
Actinide Series	90 Th 232.038 Thorium	91 Pa 231.036 Protactinium	92 U 238.029 Uranium	93 Np 237.048 Neptunium	94 Pu (244) Plutonium	95 Am (243) Americium	96 Cm (247) Curium	97 Bk (247) Berkelium	98 Cf (251) Californium	99 Es (252) Einsteinium	100 Fm (257) Fermium	101 Md (258) Mendelevium	102 No (259) Nobelium	103 Lr (262) Lawrencium

Revised October 15, 2001

Objective 1

The student will demonstrate an understanding of the nature of science.

From your studies in science, you should be able to demonstrate an understanding of the nature of science.

Nature of science? What's that?

Science is one way that people make sense of the world. Science involves asking questions about the natural world and finding ways to answer them. That's what we mean by the nature of science.

Here are just a few of the many ways to answer scientific questions: by observing the natural world, by performing experiments, by completing investigations, by doing library research, or by building models. As you can see, science is more than just a subject you study in school.

How do I do a science investigation?

First, *observe* your surroundings and ask questions about what you see. A good question for a science experiment is one that you can answer based on facts. Let's come up with one.

I know that plants need light to grow. Hmm . . . how about this for our question: Do plants grow better in some colors of light than in others? We can perform an experiment by growing plants in different colors of light. We can gather facts from our experiment to help us answer our question.

Here's a question that we couldn't use for a science investigation: Which type of music sounds better, rap or techno? The answer to the question depends on the *opinion* of the person answering it. Some people would say rap; others would say techno. We could gather only opinions about the answer to this question, not facts.

O.K., we have a question. How do we set up an experiment to answer it?

We start by making a plan. First let's narrow things down a bit. We can't really test every possible color of light, so let's pick three: red, blue, and green. And we can't test every type of plant that there is. Let's stick to just one. How about tomato plants?

Now let's think about the materials we're going to need. We'll need tomato plants, potting soil, and foam cups that we can use as pots. We'll need a way to produce different colors of light. There are several ways we could do this. We could use colored lightbulbs or different colors of plastic wrap.

We'll also need a way to make sure that our plants receive only the colors of light that we want them to. The easiest way would be to find some boxes that are big enough to set over the plants. Then we could cut off the tops of the boxes and cover them with plastic wrap in different colors.

Remember!

White light is a mixture of all colors of light. Sunlight can be separated into the colors of a rainbow because sunlight is white light.

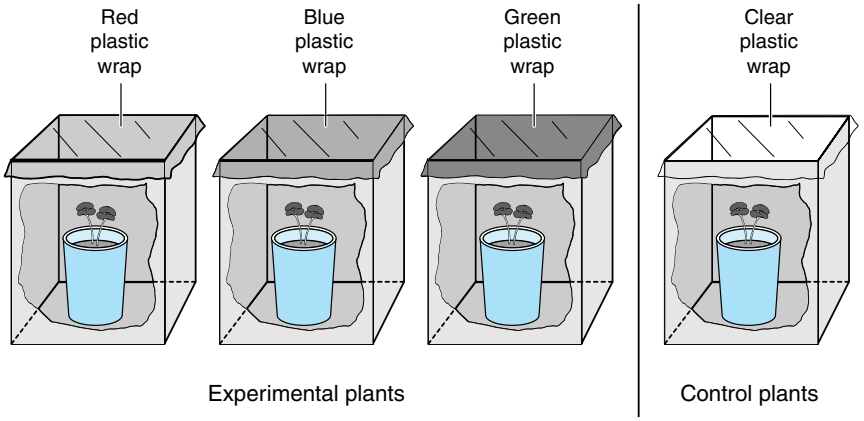
We have our materials. Are we ready to start our experiment?

Not quite yet. First we need to decide how we are going to control our variables. A *variable* is anything in an experiment that we can change. We want to keep all the variables the same except the one we are trying to test. In our experiment the variable that we are testing, the one that we will change, is the color of light. We want to keep everything else about our plants the same so that we can be fairly certain that any differences in the plants' growth are caused only by the color of light the plants receive.

To control our variables, we're going to place two tomato plants in containers of the same size and in the same type of soil. Every other day we'll give each of the containers the same amount of water.

We'll put one container in a box covered with red plastic wrap, one in a box covered with blue plastic wrap, and one in a box covered with green plastic wrap. These will be the three experimental plants. We'll put all the boxes together on a sunny porch so that they'll all receive the same number of hours of light.

Experimental Setup



Oh, I almost forgot. We're also going to need a control.

What's a control?

A *control* is something that we can compare our experimental results to. Because we're changing the color of light that the plants receive, our control can be a plant that receives all colors of light. Let's set up a fourth box and cover it with clear plastic wrap. The plant in this box will receive all colors of light and will act as our control.

I think you forgot something else. Don't we need to have a hypothesis?

Yes, we do! Do you remember the question we're trying to answer? Do plants grow better in some colors of light than in others? Let's restate our question as a *hypothesis*. A hypothesis is an educated guess about what we think will happen in our experiment based on our scientific knowledge or research. A hypothesis is also a statement that we can test. I'm going to base our hypothesis on something I already know about plants. I know plants are green, so I'm going to hypothesize that plants will grow best in green light. This is a statement that we will be able to test with our experiment.

What data do we need to collect, and how are we going to collect it?

A bunch of numbers and notes written on scraps of paper is hard to work with. So we need to get organized. First let's determine what kind of data we're going to collect. We need a way to measure plant growth. We could measure the heights of the plants or count their leaves or even measure the thickness of the stems. In science there's almost always more than one way to solve a problem or find the answer to a question.

Let's use the heights of our plants as a measure of their growth. We'll measure the heights of the plants once a week for four weeks (Weeks 1–4). We'll also measure the heights of the plants at the beginning of the experiment (Week 0). To keep up with our plant height data, we'll make a chart. We'll have one row for each week and one column for each light color. Remember, this is not the only way to organize our data.

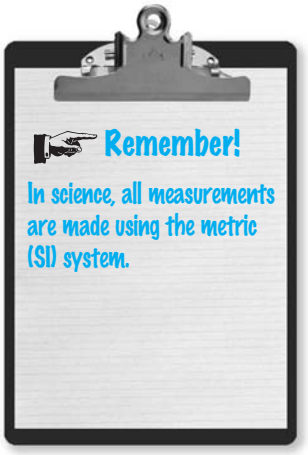
I think we're ready now. Let the experimenting begin!

Finally! If I measure the plants, will you record the measurements in our chart?

Sure. After four weeks this is what our data chart looks like.

Average Plant Height

	Red Light	Blue Light	Green Light	White Light (Control)
Week 0	1.2 cm	1.2 cm	1.2 cm	1.2 cm
Week 1	5.2 cm	4.8 cm	4.5 cm	4.6 cm
Week 2	9.4 cm	9.7 cm	8.1 cm	8.6 cm
Week 3	13.0 cm	13.8 cm	11.4 cm	11.7 cm
Week 4	16.7 cm	17.4 cm	14.0 cm	14.9 cm



So now we have lots of data. What do we do next?

We want to be able to use the data in the chart to draw a conclusion about what happened in our experiment. But it can sometimes be difficult to do this when the data are organized in a chart. Let's take our information and graph it. A graph really helps show trends. We can use a graph to compare the heights of our plants more easily.

Two types of graphs that are often used in science are line graphs and bar graphs. Line graphs are often used to show how one variable in an experiment changes over time. Bar graphs are used to display data in separate categories.

For our experiment we could use a line graph to show how the heights of the plants changed over time, or we could use a bar graph to show the heights of our four plants at the end of the experiment. Both would be good ways to show the data in our chart.

How do I set up a graph?

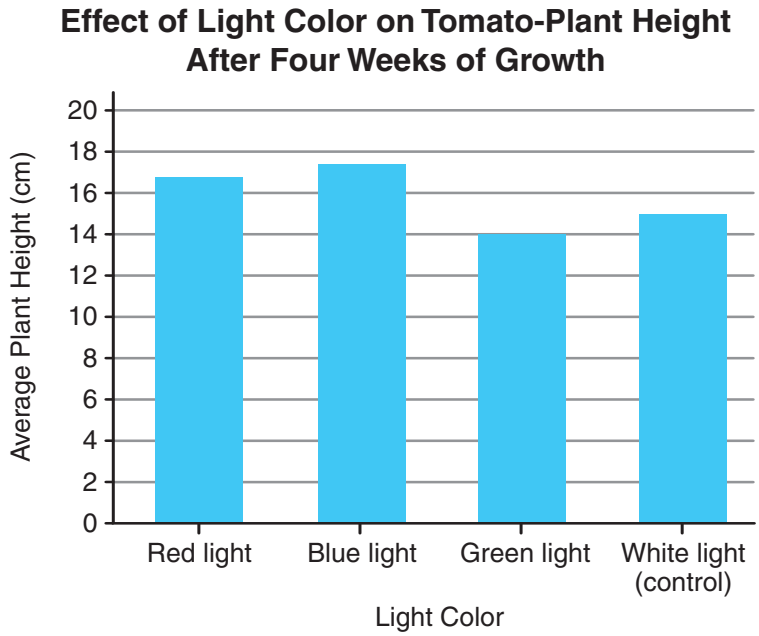
There are a few rules about what goes where on a graph. In general, the *independent* (or manipulated) variable is plotted on the horizontal axis (x), and the *dependent* (or responding) variable is plotted on the vertical axis (y). The independent variable is the variable that you change during the experiment. In our experiment the independent variable was the color of light the plants received.

The dependent variable is the one that changes as a result of the independent variable. The dependent variable is the one that you measure or observe during the experiment. In our experiment the dependent variable was the heights of the plants.

Objective 1

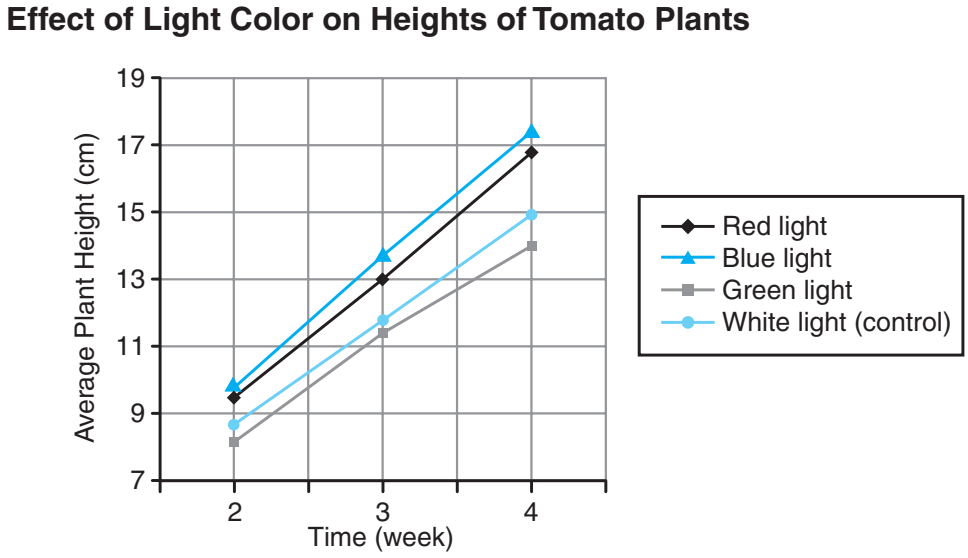
How would the data look if we used a bar graph?

Here is a bar graph of some of the data from our experiment. This graph shows the average heights of the plants after four weeks.



How would our data look if we used a line graph?

Let's use a line graph to show how the plants' heights changed during the last two weeks of the experiment. In this case time is the independent variable, and average plant height is the dependent variable. We'll use a different line for each light color.



So we've made graphs from our data. What are we supposed to do with the graphs?

Now that the data are in a graph form, we can analyze the data and make conclusions. If you look at the graphs, you should be able to see some patterns. For instance, we can see that the plants grew to different heights, so we can conclude that the color of light that the plants received may have had an effect on their growth. In order to be certain we would have to repeat this experiment many times.

We can also see that the tallest plants grew in blue light, the second-tallest in red light, the third-tallest in white light, and the shortest in green light. The tomato plants grown in red and blue light grew more than our control, and the plants grown in green light grew less than our control.

Wow! And we thought the green light would make the plants grow best. I guess our experiment was a waste of time, huh?

Of course it wasn't a waste of time! It's true that our data don't support our hypothesis, but that's O.K. A hypothesis is an educated guess; it doesn't have to be correct. Though we weren't able to support our hypothesis, we discovered that the tomato plants that grew in the blue and red light were taller. This is important information that can lead to a new hypothesis to test.

If the plants that received green light had grown taller than the others, could we have said that our hypothesis is true?

No. We performed only a single experiment, and we used only eight plants. If we repeated our experiment, we might get slightly different results. In addition, we tested only tomato plants. If we tested other types of plants, we might find that different types of plants grow best in different colors of light.

Is a hypothesis kind of like a theory?

A *theory* is a general explanation of a set of observations about the natural world. A theory helps explain how things happen the way they do in nature. Unlike a hypothesis, a theory is supported by lots of data collected from many different experiments and observations.

Theories can change over time as scientists gather more evidence. Hundreds of years ago scientists proposed a theory called spontaneous generation. This theory stated that some living things could develop from nonliving materials. For instance, it was thought that maggots could form from rotting meat. However, as scientists made more observations about the world around them, the theory of spontaneous generation was eventually replaced with the theory of biogenesis. The theory of biogenesis states that living things can come only from other living things. For example, it is now known that maggots hatch from tiny eggs that flies lay on rotting meat.

Can our data tell me why the tomato plants grew taller in red and blue light than in green light?

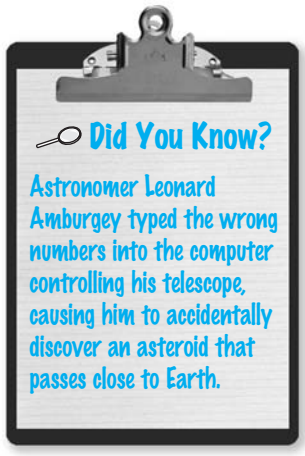
Unfortunately, our data do not answer that question. We would need to do much more research to find out how light affects plant growth. We would need to learn about the properties of red, blue, and green light. We would also need to understand how light is reflected and absorbed by plants and how plants use the light that they absorb. Maybe you could come up with another investigation!

I want to hear about an experiment in which the scientist made mistakes. Can you tell me about one?

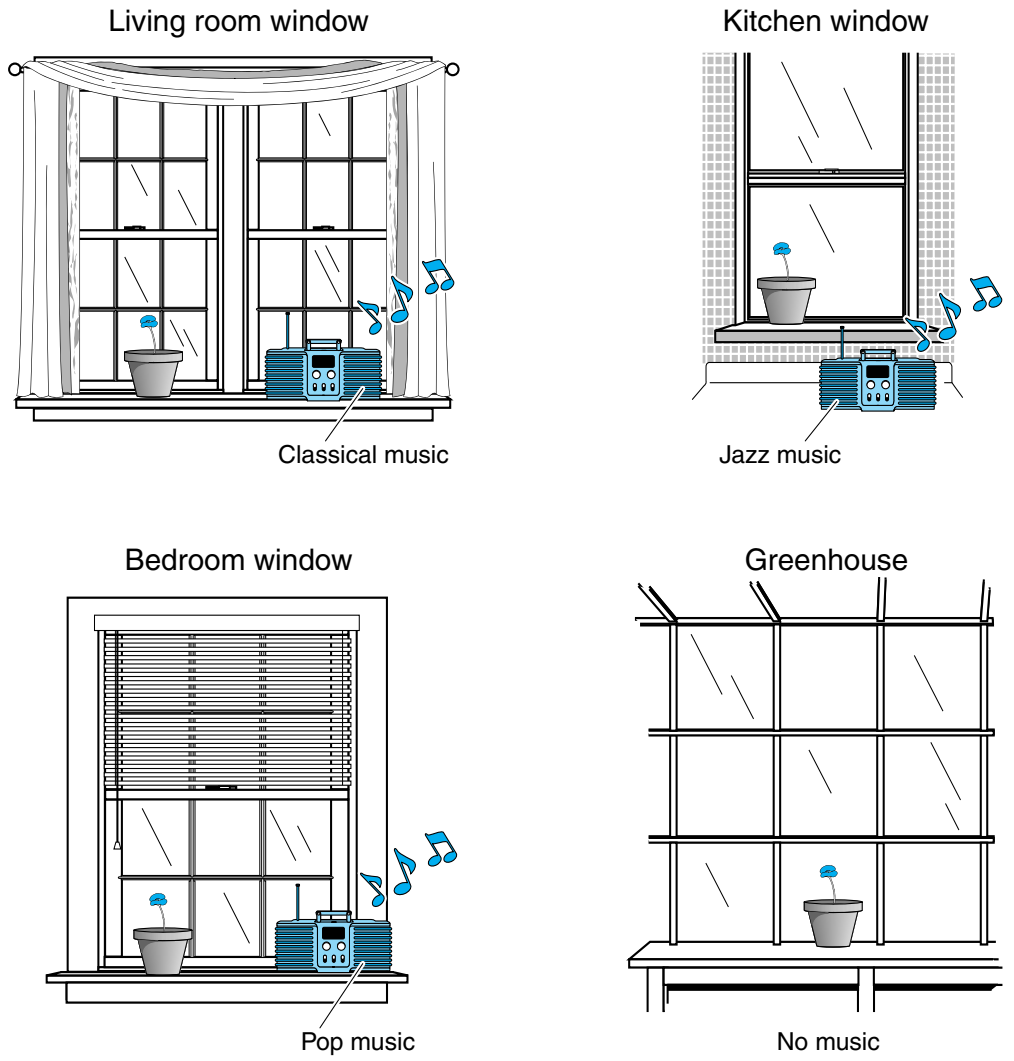
Sure! Scientists make as many mistakes as other people do. Let me tell you about an experiment that I did. I'll describe it and let you try to figure out what was wrong with it.

I wanted to figure out whether music affects plant growth. I hypothesized that classical music would make plants grow taller than jazz or pop music. I started with tomato plants that were the same age and of the same type. I gave the plants the same amount of water every other day and measured their heights each day for one month.

I put one plant in my living room window, one in my kitchen window, one in my bedroom window, and one in the school greenhouse. Each day I exposed the living room plant to six hours of classical music, the kitchen plant to six hours of jazz music, and the bedroom plant to six hours of pop music. The plant in the greenhouse wasn't exposed to any music at all.



Experimental Setup



So what happened? What kind of results did you get?

Well, I found that the plant with no music grew tallest, followed by the plant with classical music. The third-tallest plant was the one with pop music, and the shortest plant was the one with jazz music.

Can you figure out the main mistake I made in designing this experiment?

Yes! You didn't control some of your variables! The shapes and sizes of the windows are all different, and the windows are in different places.

You're right! Because the plants are in different places, they probably received different amounts of light, so I had no way of knowing which was affecting the growth of the plants—the different amounts of light they received or the music they were exposed to.

Does that mean your experiment was a total failure? Did you learn anything at all from your data?

Well, I did learn that something caused the differences in the plants' heights. I just can't be certain what that something was. One thing I could do is repeat the experiment without playing music to any of the plants. If the results of this experiment were very similar to the results of my first experiment, I could conclude that the music played in the first experiment probably had very little effect on the plants' growth. Instead, I could conclude that another factor, such as the amount of light, caused the differences in the plants' heights.

Now I know how to set up an experiment, and I know science is important, but I'm not a scientist. Why do I need to know about science?

You might not end up in a career in which you wear a white lab coat and peer through a microscope all day. But no matter what you do, you're still going to need science.

As you study science, you learn how to use and analyze the information that you are exposed to every day. Here are some examples of what you can do with a general knowledge of science: You can look at the nutrition labels on foods and make informed choices about your health. You can understand how your stereo sound system works. You can recognize which health and fitness programs sound too good to be true. You can solve problems in a logical way by looking at the facts and drawing conclusions.

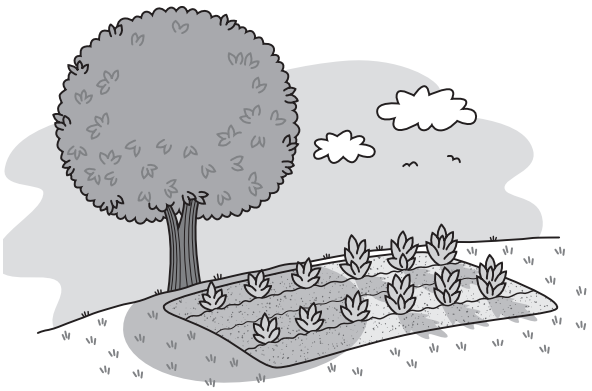
With an understanding of science, you can also understand and make educated choices on complex issues—such as global warming, cloning, and modern medicine—that will affect the future of the human race.

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose the wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 1

A student observes a garden plot. Several plants shaded by a tree are not as large as those of the same species growing in the full sun. The student asks, "Why are the plants growing in the shade smaller than the plants growing in the sun?"



Which is the most reasonable hypothesis to explain the student's observations?

A The tree removes water from the soil. The drier soil limits the growth of those plants growing near the tree.

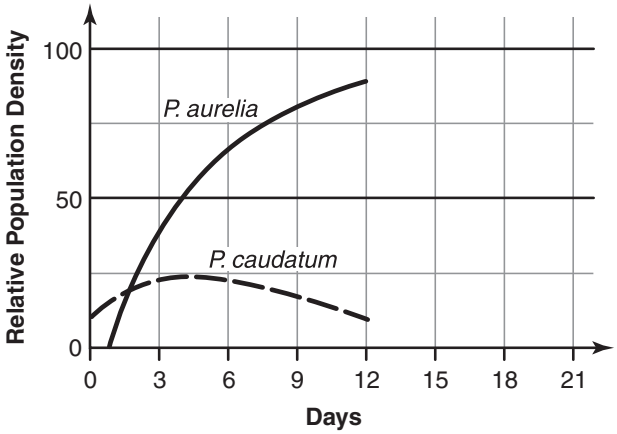
B The tree removes minerals from the soil. The mineral-reduced soil limits the growth of those plants growing near the tree.

C The tree blocks sunlight, lowering the light level in the shaded area. This limits the growth of this plant species, which grows best in direct sunlight.

D The tree blocks sunlight, lowering the air temperature of the shaded area. This limits the growth of this plant species, which grows best at warmer temperatures.

Answer Key: page 93

Question 2



Paramecium caudatum was cultured first. *Paramecium aurelia* was added to the same culture one day later. According to the graph, which is the first day that *P. aurelia* will exist alone in the culture medium if the trend shown continues?

A Day 12

B Day 13

C Day 16

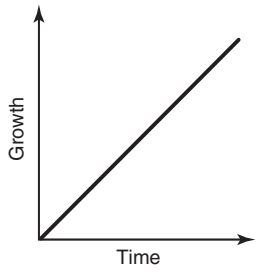
D Day 18

Answer Key: page 93

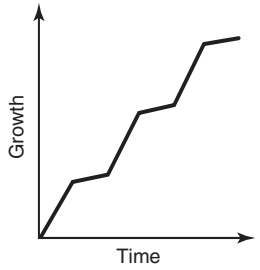
Question 3

Arthropods such as blue crabs grow in spurts. Their growth is marked by a series of molts during which the old exoskeleton is shed and a new, larger one develops. A blue crab grows rapidly only during the period between shedding and developing a new exoskeleton. Which graph most likely represents the growth of a blue crab?

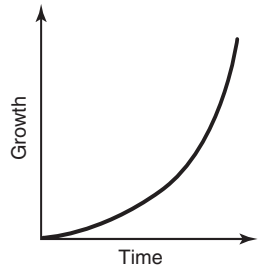
A



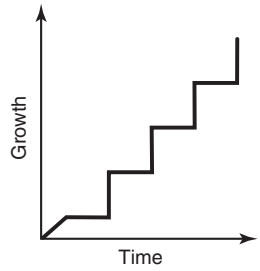
B



C

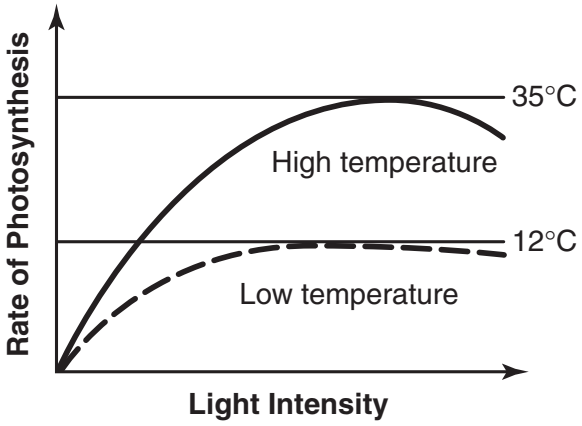


D



Answer Key: page 93

Question 4



A student performed an experiment to study the effects of the amount of light and temperature on the rate of photosynthesis in elodea plants. The graph shows the data that were obtained. Which statement is not supported by the graph?

A Low temperature reduces the rate of photosynthesis in elodea.

B The rate of photosynthesis in elodea is affected by light intensity.

C The rate of photosynthesis in elodea increases continually with increasing light intensity.

D The highest rate of photosynthesis in elodea occurs at a temperature greater than 12˚C.

Answer Key: page 93

Question 5

Which question cannot be answered by experimentation using a scientific approach?

A Does hot water freeze faster than cold water?

B Will wearing a copper bracelet reduce arthritis symptoms?

C Do roses smell better than carnations?

D Will popcorn kernels soaked in water produce a greater volume of popped corn than dry kernels?

Answer Key: page 93

Question 6

Nutrition Facts

Serving Size 8 fl oz (240 mL)
Servings Per Container 8

Amount Per Serving	
Calories 120	Calories from Fat 0
	% Daily Value*
Total Fat 0 g	0%
Sodium 20 mg	1%
Potassium 350 mg	10%
Total Carbohydrate 29 g	10%
Sugars 21 g	
Protein 0 g	
Vitamin C 100%	

Not a significant source of saturated fat, cholesterol, dietary fiber, calcium, vitamin A and iron

* Percent Daily Values are based on a 2000-Calorie diet.

According to the nutrition label above, what is the total daily requirement for carbohydrates based on a 2000-Calorie diet?

A 29 grams

B 290 grams

C 20 milligrams

D 350 milligrams

Answer Key: page 94

Question 7

Research has shown an association between the use of aspirin or similar products and the development of a potentially deadly disease of the brain and liver called Reye's syndrome. This disorder sometimes occurs when aspirin or medicines containing salicylate compounds are administered during recovery from a viral infection, such as a cold, the flu, and chicken pox. Based on the information below, which nonprescription medicine is considered unsafe to take while recovering from a viral infection?

A Multisymptom cold medicine

ACTIVE INGREDIENTS (1 fluid ounce)
Doxylamine Succinate (12.5 mg), Dextromethrophan Hydrobromide (30 mg), Acetaminophen (1000 mg), Pseudoephedrine Hydrochloride (60 mg)
INACTIVE INGREDIENTS
Alcohol, Citric Acid, FD&C Blue No. 1, FD&C Red No. 40, Flavoring, High-Fructose Corn Syrup, Polyethylene Glycol, Propylene Glycol, Purified Water, Saccharin Sodium, Sodium Citrate

B Motion-sickness tablet

ACTIVE INGREDIENT (per tablet)
Dimenhydrinate (50 mg)
INACTIVE INGREDIENTS
Colloidal Silicon Dioxide, Croscarmellose Sodium, Lactose, Magnesium Stearate, Microcrystalline Cellulose

C Medicine for an upset stomach

ACTIVE INGREDIENT (per tablespoon)
Bismuth Subsalicylate (262 mg)
INACTIVE INGREDIENTS
Benzoic Acid, Flavoring, Magnesium Aluminum Silicate, Methylcellulose, Red 22, Red 28, Saccharin Sodium, Salicylic Acid, Sodium Salicylate, Sorbic Acid, Water

D Chewable antacid tablet

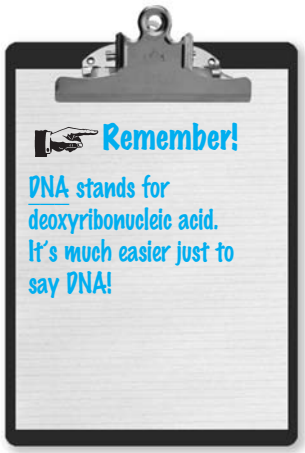
ACTIVE INGREDIENTS (per tablet)
Famotidine (10 mg), Calcium Carbonate (800 mg), Magnesium Hydroxide (165 mg)
INACTIVE INGREDIENTS
Cellulose Acetate, Corn Starch, Dextrates, Flavoring, Hydroxypropyl Cellulose, Hydroxypropyl Methylcellulose, Lactose, Magnesium Stearate, Pregelatinized Starch, Red Iron Oxide, Sodium Lauryl Sulfate, Sucrose

Answer Key: page 94

Objective 2

The student will demonstrate an understanding of the organization of living systems.

From your studies in biology, you should be able to demonstrate an understanding of the organization of living systems.



Living systems are organized?

All living things are made up of one or more cells that contain genetic material called DNA. In many organisms, cells are organized into tissues, organs, and organ systems. Organisms are organized into populations and communities. You need to be able to show that you understand the different levels of organization.

I know that organisms are made up of cells. But what do cells do? And how do they work?

Cells are the basic units of all living things. They carry out the life functions of an organism. In some ways, cells are a lot like factories. A furniture factory, for example, takes in raw materials such as wood, turns them into finished products such as chairs and tables, and then sends them out. The factory also needs a source of energy to run its tools, and it must get rid of wastes such as sawdust.

Cells take in raw materials, such as *amino acids*, change them into more-complex molecules such as proteins, and then transport these molecules to where they are needed. Cells produce energy for life processes by breaking down molecules like glucose. They also get rid of waste molecules produced by these processes.

So how do cells make things?

Cells don't make just anything. They make molecules. And the process by which cells make molecules is called *synthesis*. One important molecule synthesized by plant cells is glucose. Plant and animal cells use glucose as an energy source.

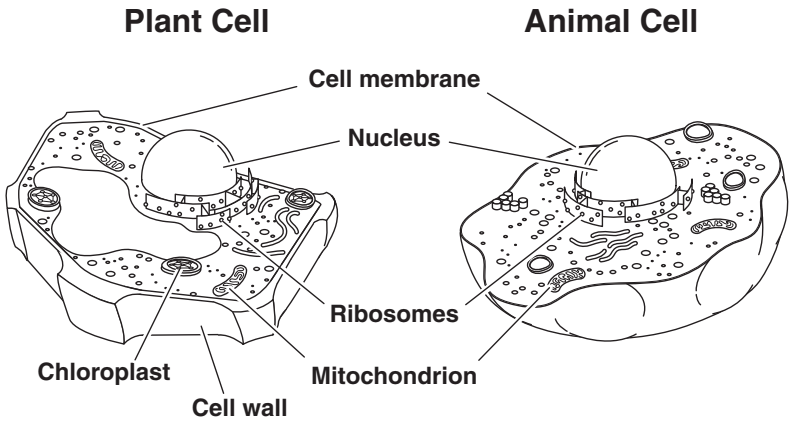
The synthesis of glucose by plant cells can be summed up with this chemical reaction:

$$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

$$\text{carbon dioxide} + \text{water} \xrightarrow{\text{light}} \text{glucose} + \text{oxygen}$$

In plants, this process takes place in *organelles* called *chloroplasts*. It requires light energy. For this reason, the process is called *photosynthesis*. (*Photo-* means "light.")

Animal cells also use glucose as an energy source. However, animal cells can't make glucose because they lack chloroplasts. So where do animals get glucose? They get it from eating plants or from eating animals that eat plants.



What about proteins? How are they synthesized?

Proteins are complex molecules that have many functions in living things. For instance, they are one of the main building materials in cells. Remember that proteins are made up of smaller units called amino acids. The process by which amino acids are linked together to form a protein is called *protein synthesis*.

Protein synthesis takes place on a cell's *ribosomes*. All types of cells have ribosomes, even bacterial cells. This means that all types of cells are able to make their own proteins. Remind me to tell you more about protein synthesis once we've talked about DNA.

DNA? That's genetic material, right?

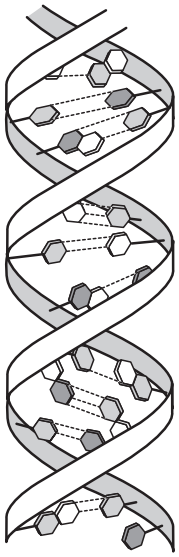
Right! DNA carries the genetic information that controls the activities of a cell. It carries instructions that determine which proteins the cell will make. You inherited your DNA from your parents. Half of your DNA came from your mother, and half came from your father. A basic understanding of genetics will help you understand issues about your health, cloning, and other types of genetic engineering.

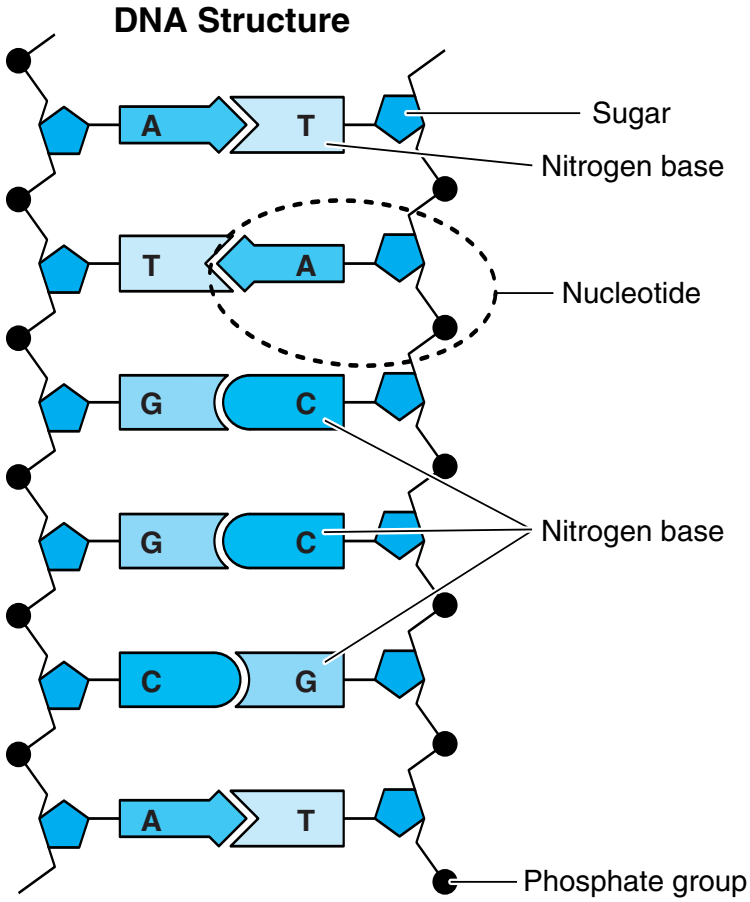
How does DNA "carry" genetic information?

Genetic information is carried within the DNA molecule itself—in its structure. DNA is made up of units called *nucleotides*. Each nucleotide has three parts: a sugar called deoxyribose, a phosphate group, and a nitrogen base. There are four different nitrogen bases in DNA: guanine (G), cytosine (C), adenine (A), and thymine (T).

A DNA molecule looks like a twisted ladder. This shape is often called a *double helix*. The diagram below models a small section of DNA that has been "flattened" so that you can see its parts.

Segment of a DNA Molecule





The DNA "ladder" is made up of two strands of nucleotides. Sugars and phosphates make up the sides of the ladders. Each rung of the ladder is made up of two nitrogen bases, one from each strand. The same bases always bond with each other: cytosine with guanine, and adenine with thymine.

O.K., now I know about the parts of DNA, but I still don't see where the genetic information is. Can you show me?

Yes! In fact, you've already seen it. Look back at the model of DNA. The genetic information is coded in the order of the bases in a DNA molecule. For instance, if you look down the left side of the DNA structure, the order is ATGGCA.

I see it now! But how is this genetic code actually used for anything?

The genetic code is used as a blueprint to make proteins. First the genetic code in a section of DNA is *transcribed* to a molecule of mRNA. (Transcribed is a fancy way of saying "copied.") RNA is very similar to DNA except that it:

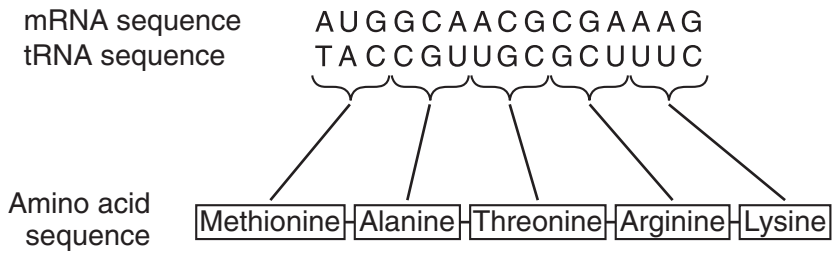
- has only a single strand of nucleotides instead of two strands
- contains a different sugar (ribose instead of deoxyribose)
- contains the nitrogen base uracil (U) instead of thymine (T)

The "m" in "mRNA" stands for "messenger," because mRNA copies genetic information from DNA (which is found in the nucleus) and carries it to another part of the cell (the ribosomes).

O.K., we've gone from DNA to mRNA. How do proteins fit into all this?

I'm getting to that. Think of the genetic code the mRNA is carrying as a series of three-letter "words." Each of these three-letter words is called a *codon*. Different codons code for different amino acids. For example, the codon for the amino acid methionine is AUG (adenine, uracil, guanine). Another type of RNA, called tRNA ("t" stands for "transfer") matches the codons in mRNA to the correct amino acids. As the mRNA strand moves along the ribosome, the amino acids are joined in the correct sequence to form a protein. This process is called *translation*.

Translation of mRNA Codons



Does the DNA sequence ever get messed up?

Good question. Yes, it does. When this happens, we call it a *mutation*. A mutation is a change in the nucleotide sequence of DNA. And as you can probably guess, a change in DNA leads to a change in mRNA, which can lead to a change in protein synthesis. Some mutations can be harmful or even fatal to an organism. However, most mutations have little or no effect on an organism.

Other types of mutations affect more than one codon. For instance, a mutation can cause one or more nucleotides to be added to or deleted from DNA. This type of mutation can lead to the production of a completely different protein. As a result, the mutation could be harmful, or even fatal, to the organism.

Aren't there any good mutations?

Yes, there are! On rare occasions, a mutation can make an organism more likely to survive and reproduce. For example, a species of plant might produce a chemical with a scent that attracts pollinating flies. A mutation in one of the plants could make it produce a slightly different scent—one that is even more attractive to pollinators. This type of mutation would be beneficial to the plant.

However, even if a mutation benefits an organism, it may not be passed on to the organism's offspring. For organisms that reproduce sexually, mutations can be passed to the next generation only if they occur in the organism's sex cells (eggs or sperm).

You said that most mutations don't have an effect on an organism. How can that happen?

For one thing, not all mutations lead to a different protein being made. There are more codons than there are amino acids. So, more than one codon can code for the same amino acid. The diagram below shows a codon chart. A codon chart shows which codons code for which amino acids.

Suppose a DNA mutation led to a change in a single mRNA codon. Now suppose this codon changed from GCC to GCG. By looking at the codon chart, you can see that both of these codons code for the amino acid alanine. So even though the DNA and mRNA have changed, there is no change in the protein!

mRNA Codons and Amino Acids

Codon — Amino Acid

First Base	Second Base: U	Second Base: C	Second Base: A	Second Base: G	Third Base
U	UUU, UUC: Phenylalanine UUA, UUG: Leucine	UCU, UCC, UCA, UCG: Serine	UAU, UAC: Tyrosine UAA, UAG: Stop	UGU, UGC: Cysteine UGA: Stop UGG: Tryptophan	U C A G
C	CUU, CUC, CUA, CUG: Leucine	CCU, CCC, CCA, CCG: Proline	CAU, CAC: Histidine CAA, CAG: Glutamine	CGU, CGC, CGA, CGG: Arginine	U C A G
A	AUU, AUC, AUA: Isoleucine AUG: Methionine	ACU, ACC, ACA, ACG: Threonine	AAU, AAC: Asparagine AAA, AAG: Lysine	AGU, AGC: Serine AGA, AGG: Arginine	U C A G
G	GUU, GUC, GUA, GUG: Valine	GCU, GCC, GCA, GCG: Alanine	GAU, GAC: Aspartic Acid GAA, GAG: Glutamic Acid	GGU, GGC, GGA, GGG: Glycine	U C A G

This chart shows the amino acids coded for by each of the 64 possible mRNA codons. To find which amino acid the codon CAA codes for, follow these steps. (1) Look on the left side of the chart to find the large row of codons that begin with C. (2) Move across this row until you get to the column of codons whose second base is A. (3) Move down this column until you get to the row of codons whose third base is A. The codon CAA codes for the amino acid glutamine.

When we studied DNA in class, we learned about genetics. My teacher kept using the word *allele*. What's an allele?

Let's start with some background information. For each of your inherited traits, you inherit one gene from your mother and one from your father, which means you have two copies of most genes. (The only exception involves sex chromosomes in males.)

Genes can have different forms called *alleles*. For example, the genes that determine flower color in pea plants have two alleles: one for purple (called P) and one for white (called p). A pea plant could inherit two purple alleles (PP), two white alleles (pp), or one of each (Pp).

Remember!

Dominant alleles are represented by capital letters, and recessive alleles are represented by lowercase letters.

O.K., a plant with two purple alleles would have purple flowers, and a plant with two white alleles would have white flowers. But what about a plant with one purple allele and one white allele?

A pea plant with one of each type of allele (Pp) would have purple flowers. This is because the purple allele (P) is dominant. A *dominant allele* is one that is expressed (or visible) in an organism even if the organism has only one copy of it. The white allele (p) is recessive. A *recessive allele* is one that is expressed in an organism only if the organism has two copies of it. Pp is the plant's genotype, and purple flowers is the plant's phenotype.

What's the difference between genotype and phenotype?

The *genotype* tells you which alleles the organism has. And the *phenotype* tells you which form of the trait is expressed in the organism.

Remember!

An organism is homozygous for a trait when it has two copies of the same allele. It is heterozygous for a trait when it has two different alleles.

How can you use genetics to make predictions?

Scientists might use a tool called a *Punnett square*. A Punnett square is used to predict the possible genotypes and phenotypes of offspring. Let's continue to use the example of pea plants. Suppose we cross two plants with purple flowers and genotypes of Pp. The Punnett square below allows us to make predictions about their offspring.

Punnett Square

Parent 2: Pp \ Parent 1: Pp	P	p
P	PP	Pp
p	Pp	pp

The alleles of one parent are put along the top of the Punnett square. The alleles of the second parent are put along the left side of the Punnett square. The boxes in the Punnett square are filled in with combinations of the parents' alleles. These combinations are the possible genotypes of the offspring.

Genotypes and Phenotypes Predicted by the Punnett Square Shown in Three Different Formats

	Fraction	Percent	Ratio
Genotype	$\frac{1}{4}$ PP	0.25 = 25% PP	1 PP : 2 Pp : 1 pp
	$\frac{2}{4} = \frac{1}{2}$ Pp	0.50 = 50% Pp	
	$\frac{1}{4}$ pp	0.25 = 25% pp	
Phenotype	$\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$ purple	0.75 = 75% purple	3 purple : 1 white
	$\frac{1}{4}$ white	0.25 = 25% white	

Are all genetics problems so simple?

Punnett squares are very basic tools for scientists to use when predicting traits that are simple. But genetics can be very complicated. For instance, humans have 23 pairs of chromosomes and about 30,000 different genes. You should always remember that there are two alleles for each gene, which allows for millions of different combinations. Also, one pair of chromosomes, the sex chromosomes, determine if you are a male or a female, as well as controlling some other traits. The other 22 pairs, the autosomal chromosomes, have little influence on your gender but control most of your other traits. When you consider all of these factors and many more that we are discovering every day, you can see that genetics can be very complicated as well as very important.

Do all plants and animals have the same genes?

No, but some organisms are closely related. Grouping organisms into categories helps scientists find information about living things more easily. For instance, if you know that a cobra is a snake, you know that it has scaly skin and no legs. Biologists group organisms into categories based on how closely related the organisms are. Classifying living things in this way helps biologists study how organisms have changed over time.

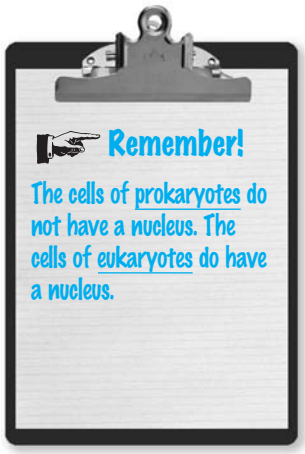
What are these categories?

First of all, living things are classified into large groups called kingdoms. Each kingdom is divided into smaller groups, these smaller groups are divided into even smaller groups, and so on. These groups, from largest to smallest, are *kingdom*, *phylum*, *class*, *order*, *family*, *genus*, and *species*.

Objective 2

How many kingdoms are there? And what's in them?

Today the most widely used classification system contains six kingdoms. This system has changed over the years to include new information. The following list shows the names and major characteristics of the six kingdoms.



- **Archaebacteria:** This kingdom includes unicellular (one-celled) prokaryotes that often live in extreme environments. Some archaebacteria are *autotrophs* (make their own food), and some are *heterotrophs* (cannot make their own food). Examples of archaebacteria include the bacteria that live in hot springs.
- **Eubacteria:** This kingdom also includes unicellular prokaryotes that may or may not make their own food. However, most eubacteria do not live in extreme environments. Examples of eubacteria include the bacteria that cause strep throat.
- **Protista:** This kingdom includes mostly one-celled eukaryotes. However, there are a few protists that are multicellular. Protists may be autotrophs or heterotrophs. Examples of protists include amoebas, slime molds, and algae.
- **Fungi:** Most fungi are multicellular eukaryotes, although there are a few unicellular fungi. All fungi are heterotrophs with cell walls. Examples of fungi include mushrooms, yeasts, and molds.
- **Plantae:** Plants are multicellular eukaryotes. They have cell walls and specialized tissues and organs. Plants can make their own food, so they are autotrophs. Examples of plants include mosses, ferns, trees, and grasses.
- **Animalia:** Like plants, animals are also multicellular eukaryotes with specialized tissues and organs. However, animals are heterotrophs and lack cell walls. Examples of animals include worms, insects, fish, birds, reptiles, and mammals, including humans.

How do scientists know which group to place organisms in?

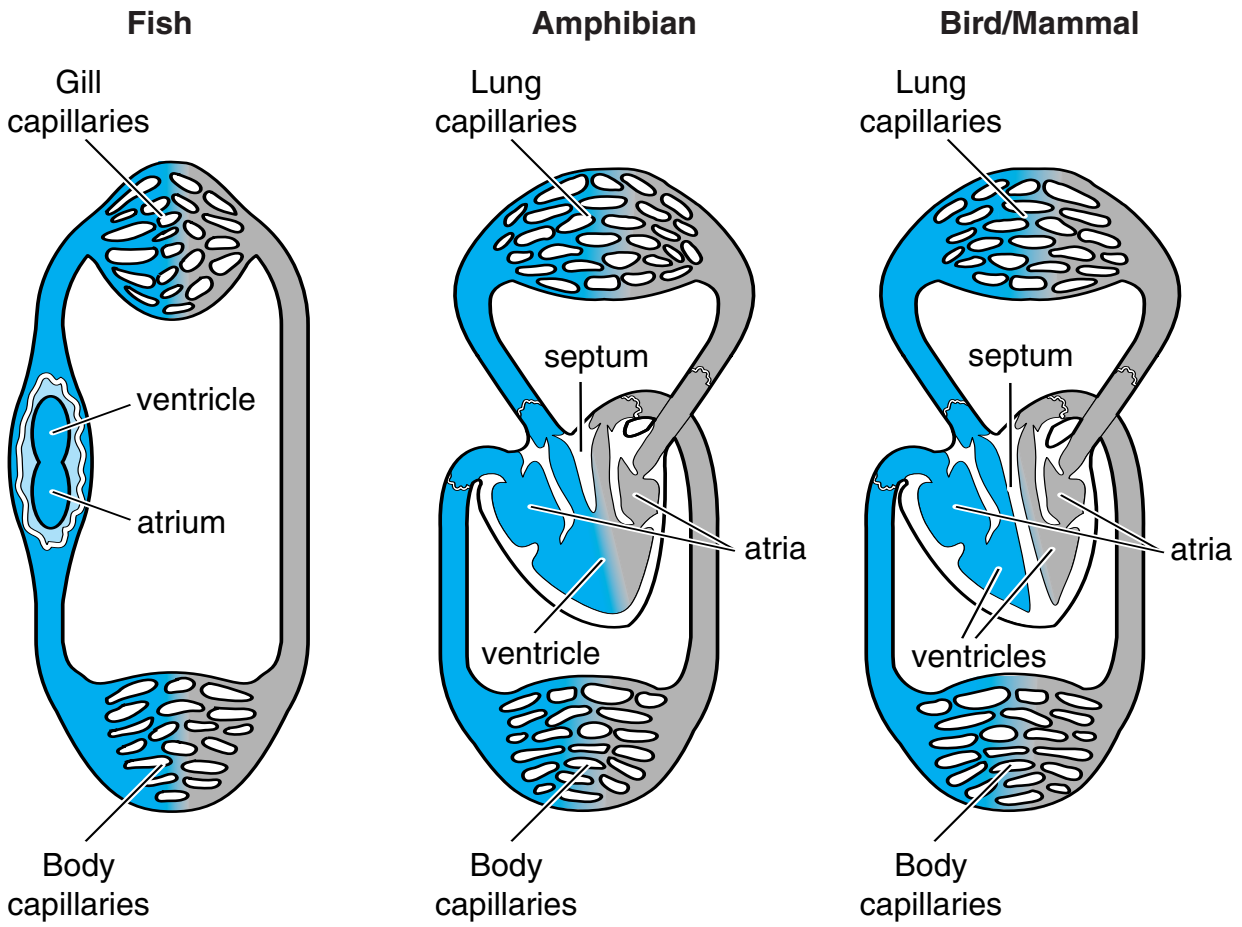
Scientists classify organisms based on a variety of characteristics, including genetic makeup, body chemistry, physical structures, and more. Let's use the transportation of materials as an example of one characteristic that scientists use to classify some types of organisms.

All living things must be able to transport materials such as nutrients and oxygen within their bodies. Organisms that are closely related have similar structures to accomplish transport.

Archaebacteria, eubacteria, and most protists are one-celled organisms. Because they are so small, they do not need to transport materials great distances, and they do not have well-developed transport systems. Some protists, however, have organelles called *contractile vacuoles*. These organelles collect excess water and pump it out of the cell.

Even though many fungi are multicellular, they lack circulatory systems. Instead, materials within fungi are transported directly from cell to cell. By contrast, many plants have specialized transporting tissues called *xylem* and *phloem*. Xylem transports water and minerals throughout a plant, and phloem transports sugars from one part of a plant to another. We'll talk more about this in Objective 3.

Animals have the most-developed transport systems of all. In animals the transport system is called the *circulatory system*. The circulatory system of many animals includes a heart that pumps blood throughout the body. The blood travels in vessels and carries nutrients, oxygen, and waste products such as carbon dioxide.



Fish have a two-chambered heart, amphibians have a three-chambered heart, and birds and mammals have a four-chambered heart. Fish have a circulatory system with a single loop. Amphibians, birds, and mammals have a circulatory system with two loops, one to the lungs and one to the body.

I think I know the parts of the body systems. Can you tell me what the systems do?

Here's a review of the body systems and how they function.

- **Circulatory**: The circulatory system transports oxygen and nutrients to cells and carries wastes away from cells.
- **Respiratory**: The respiratory system moves oxygen into the body and carbon dioxide out of the body.
- **Digestive**: The digestive system digests (breaks down) food and absorbs nutrients.
- **Nervous**: The nervous system detects changes outside and inside your body and controls the way your body responds to these changes.
- **Skeletal**: The skeletal system helps you move, protects your internal organs, and gives your body shape and support. It also stores minerals and produces blood cells.
- **Muscular**: The muscular system is responsible for voluntary movements (such as jumping and pointing) and involuntary movements (such as the beating of your heart and the churning of your stomach).
- **Endocrine**: The endocrine system produces chemical messengers called hormones. Some hormones help to maintain homeostasis. Others control development and growth.
- **Integumentary**: The integumentary system (skin) forms a protective barrier around the body. The skin helps prevent water loss and control body temperature. It also gathers information about your surroundings.
- **Immune**: The immune system protects the body from infection.
- **Lymphatic**: The lymphatic system takes fluid from the spaces between cells and returns it to the circulatory system. It also filters bacteria and other microorganisms from this fluid.
- **Reproductive**: In males the reproductive system produces sperm, and in females the reproductive system produces eggs.
- **Excretory**: The excretory system removes wastes from the body and helps maintain homeostasis.

I don't understand homeostasis. Can you explain it?

When you think of *homeostasis*, think of Goldilocks. Goldilocks couldn't have her porridge too hot or too cold. Her bed couldn't be too hard or too soft. Everything had to be "just right."

What does a fairy tale have to do with science?

Cells are much the same. For example, the fluid that surrounds them can't be too hot, too salty, or too acidic, or they'll die. Everything has to be just right in order for them to survive. Now, here's where homeostasis comes in. Homeostasis refers to an organism's ability to maintain a stable internal state. In other words, homeostasis is the ability of an organism to keep everything just right for its cells.

But how do organisms keep things "just right"?

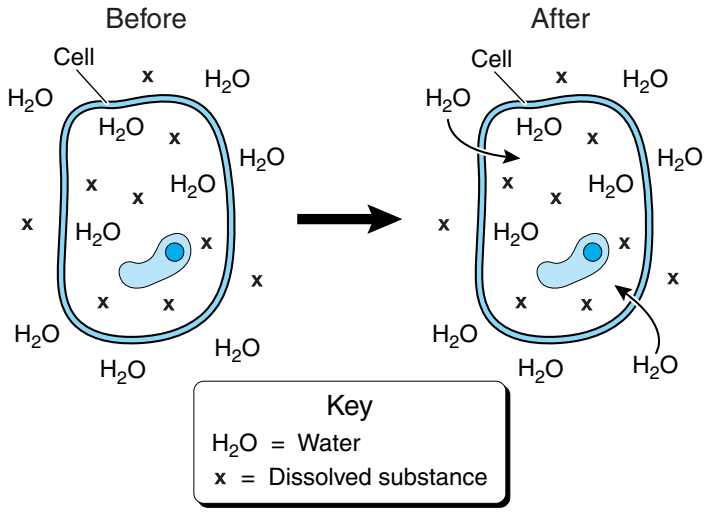
There are many chemical reactions and physical processes that organisms use to maintain homeostasis. Let's look at one example involving *osmosis*. Osmosis is the diffusion of water across a *semipermeable membrane* such as a cell membrane. A semipermeable membrane is one that only certain types of molecules can cross. For example, water can cross a cell membrane, but many other substances can't.

Remember!

Diffusion is the movement of molecules from an area of high concentration to an area of low concentration.

Cell membranes can do this because they are made of two layers of lipids called a *lipid bilayer*. Each layer of lipid has a polar side and a nonpolar side. In a lipid bilayer, the nonpolar sides are facing each other, and the polar sides are on the outside. The nonpolar interior of the cell membrane prevents ions and large uncharged molecules, such as sugar, from passing through the membrane. However, floating in the cell membrane are transport proteins that will allow certain molecules, even large molecules, to enter the cell. We'll talk more about polar molecules in Objective 4.

Osmosis



The net direction of osmosis through a cell membrane depends on the concentration of dissolved substances inside and outside the cell. Osmosis involves the movement of water from the side with a lower concentration of dissolved substances (higher concentration of water) to the side with a higher concentration of dissolved substances (lower concentration of water).

As the diagram shows, osmosis helps keep the concentration of dissolved substances inside and outside the body's cells nearly the same. There is more dissolved substance inside the cell than outside the cell. So, over time water will move into the cell.

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose the wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 8

What is one reason that dehydrated patients are given intravenous (IV) solutions of pure water with a small amount of dissolved salt rather than just pure water?

A To help prevent cells from shriveling because of the pressure caused by osmosis

B So that the pressure caused by osmosis will cause a net movement of salt into cells

C So that dissolved substances will be transported across cell membranes and out of cells

D To help keep the concentrations of dissolved substances inside and outside the cells equal

Answer Key: page 94

Question 9

As an athlete is running a 5-kilometer race, her cells need more oxygen. Which change will help her body meet the increased demand for oxygen?

A Her heart beating more quickly

B Her pancreas releasing more insulin

C Her breathing becoming more shallow

D Her sweat glands becoming more active

Answer Key: page 94

Question 10

Allele	Symbol
Low-yield	H
High-yield	h
Rapidly maturing	M
Slow-growing	m
Tall	T
Short	t
Yellow kernels	Y
White kernels	y

An agricultural scientist wants to develop a variety of corn that will mature rapidly and will produce high yields. Which genotypes should the scientist cross to produce the most plants with the desired characteristics?

A hhmmTtyy × hhMMttyy

B HHmmttyy × hhMMttyy

C hhMmttyy × HhmmttYY

D HHmmttyy × hhMmttYy

Answer Key: page 94

Question 11

	DNA	mRNA	Phenotype
Normal	C-T-T→	G-A-A→	Normal blood cells
Mutation 1 (sickle-cell mutation)	C-**A**-T→	G-**U**-A→	Sickle-shaped blood cells
Mutation 2	C-T-**C**→	G-A-**G**→	Normal blood cells

What is one possible reason that Mutation 2 leads to the production of normal blood cells rather than sickle-shaped blood cells?

A The mRNA codons GAA and GAG both code for the same amino acid.

B The mRNA codon GAG acts as a stop signal rather than coding for an amino acid.

C The mRNA codon GAG is unreadable and is therefore skipped over during protein synthesis.

D The mRNA codon GAG corresponds to the tRNA molecule that can carry more than one amino acid.

Answer Key: page 95

Question 12

Histamine is a polar chemical that can lead to an allergic response when it is released by the body's immune system. An antihistamine is a drug that can help prevent the allergic reactions associated with histamine. An antihistamine is a similar molecule to histamine in size, shape, and polarity. How does an antihistamine most likely prevent the effects of histamine?

A It increases the diffusion of histamine across the membranes of target cells.

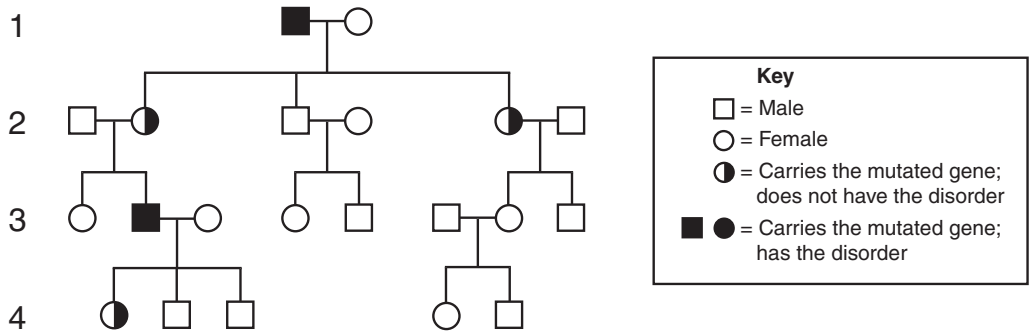
B It binds to histamine receptors on the surfaces of target cells.

C It causes target cells to increase production of histamine receptors.

D It blocks histamine receptors found in the cytoplasm of target cells.

Answer Key: page 95

Question 13



Duchenne muscular dystrophy is a genetic disorder. It results from a mutation in the gene that codes for a protein necessary for muscle strength. A geneticist prepared a pedigree for a family in which the disorder is present in some members. According to this information, what type of allele is responsible for Duchenne muscular dystrophy?

A Autosomal recessive

B Autosomal dominant

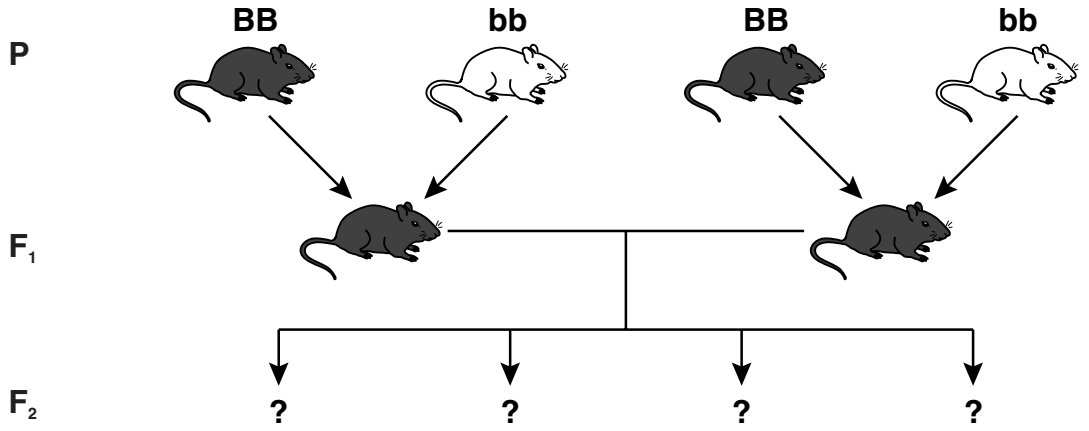
C Sex-linked recessive

D Sex-linked dominant

Answer Key: page 95

Question 14

When a black mouse that is homozygous for coat color (BB) is crossed with a white mouse that is homozygous for coat color (bb), all of the F_1 generation offspring have black coats.



What are the expected genotypes and phenotypes of coat color in the F_2 generation?

A All F_2 mice have BB genotypes and black phenotypes.

B All F_2 mice have bb genotypes and white phenotypes.

C The genotypes of the F_2 mice are 25% BB, 50% Bb, and 25% bb. The phenotypes are 75% black and 25% white.

D The genotypes of the F_2 mice are 50% BB and 50% bb. The phenotypes are 50% black and 50% white.

Answer Key: page 96

Objective 3

The student will demonstrate an understanding of the interdependence of organisms and the environment.

From your studies in biology, you should be able to demonstrate the interdependence of organisms and the environment.

Wait a minute! What am I supposed to demonstrate?

Organisms don't live in isolation. All living things depend on their environment and other organisms for survival. In other words, every living thing is part of an *ecosystem*. You need to be able to show that you understand this dependence of organisms on one another.

What's an ecosystem?

An ecosystem is an interactive system that includes all parts of the physical environment (*abiotic* factors such as temperature, soil, and weather). It also includes the entire community of organisms that live there (*biotic* factors such as plants, animals, fungi, and bacteria).

Although it's easy to think of ourselves as separate from the environment, we are actually part of an ecosystem. Humans often see themselves as independent of nature, but nothing could be further from the truth.

We depend on nature for basic resources such as food and shelter, clean air, and clean water. Life can exist only within an ecosystem.

So some animals eat other animals; what's the big deal?

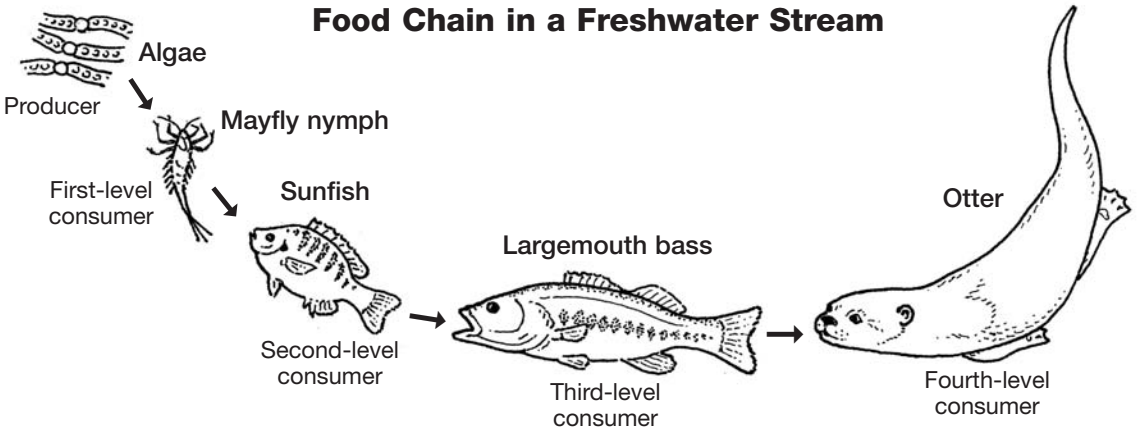
The flow of energy through an ecosystem determines what kinds of organisms live there and how many organisms the ecosystem can support. This is called the *carrying capacity* of the ecosystem. Many organisms obtain the matter and energy that they need to survive by eating other organisms. I don't know how you feel, but surviving is a big deal to me!

Eating another animal is just one of the many ways that matter is cycled through an ecosystem.

Ecosystems can be studied by looking at how energy flows through different feeding levels (for example, *producers*, *consumers*, and *decomposers*). These feeding relationships are also called *trophic levels*. Consider the following important concepts about the flow of energy in an ecosystem:

- Organisms contain chemical energy that is stored in organic molecules, such as sugars, starches, and proteins.
- Energy flows through ecosystems in food chains and food webs every time an organism eats another organism.

- Energy flows in one direction only: from the sun to producers and then to consumers. Energy cannot be recycled. Most energy is released as heat. This means that it cannot be used to do work.



The organisms in each higher level can store only about 10 percent of the energy available in an organism that it eats. About 90 percent of the energy consumed is used to maintain the organism's life functions (metabolism) or lost as undigested food and waste heat. Only about 10 percent is used to make new cells.

Remember that a food chain shows how populations of organisms relate to populations of other organisms.

What's a population?

A *population* is a group of individual organisms that belong to the same species, live in the same general area, and breed with other individuals in the group. Over time the genetic makeup of a population can change in order to adapt to the changes in the environment. This is called *evolution*.

Remember!

A food chain is just a part of a more complex food web.

Evolution and natural selection are kind of the same thing, right?

Many students are confused about the difference between evolution and *natural selection*. To *evolve* means to change over time. Stars evolve, languages evolve, and in biology, living things evolve. Evolution is the change in the genetic makeup of populations and species over many generations.

But what about natural selection?

It's kind of like cause and effect. Natural selection is the cause, and evolution is the effect. Let me explain how the process of natural selection causes change within populations of organisms.

Organisms vary because of differences in inherited characteristics, or traits. We talked about that in Objective 2. Individuals with physical and behavioral traits that are better adapted to an environment are more likely to survive, reproduce, and pass those traits on to their offspring. This process is sometimes called *survival of the fittest*.

As those individuals with favorable traits in a population produce more offspring, the favorable traits become more common in the population. Over many generations the genetic makeup of a population can evolve.

Remember!

A species is a group of organisms that are capable of interbreeding and producing fertile offspring.

The environment puts pressure on all organisms. Those that are adapted to survive live to reproduce. Over time the process of natural selection can lead to the evolution of a new species.

Are you saying that individual organisms don't evolve?

That's right. Now you've got it! The genetic makeup of an organism doesn't change during its lifetime, so it can't evolve. But the genetic makeup of a population changes with each new generation. So populations can evolve.

Sharks (fish) and dolphins (mammals) are not closely related. They've evolved bodies of a similar shape because these animals have adapted to the same environment. Both are fast swimmers and can accelerate quickly in water to catch prey.

Are animals the only things that evolve?

No, all organisms evolve. Bacteria evolve very quickly. Even fungi and plants evolve.

More than half the Calories consumed by humans come from wheat, corn, and rice.

Speaking of plants, why are they important?

Can you imagine a world without plants? I can't! Think about the foods you eat. Many foods are made from plants in the grass family. These plants produce cereal grains such as wheat, corn, rice, and oats. These grains are used to make foods, such as:

- bread
- tortillas
- spaghetti
- popcorn

But I had a hamburger and a glass of milk for lunch. These foods don't come from plants!

You're right, of course. These foods come from animals. But consider what cows eat. They eat plants. And where do you think that hamburger bun came from?

Remember!

Biomass is the total dry mass of a group of organisms living in a given area.

O.K., so plants provide food. Are they good for anything else?

Yes! Plants are important for a lot of other reasons:

- Plants play an important role in the *carbon cycle*. They remove carbon dioxide from the atmosphere and release oxygen. Without plants the oxygen currently in Earth's atmosphere would last only about 11 years.
- Plants are the dominant group of organisms on land, if *biomass* is considered. Biomass is the dry mass of tissue and organic matter

in an ecosystem. It is an important source of energy and the most significant fuel worldwide after coal, oil, and natural gas.

- Plants play an important role in the water cycle and even affect climate. They also help prevent erosion.
- Plants store and recycle essential nutrients through the biosphere. They change energy from the sun into forms of energy that animals can use.
- Plants provide many useful products, such as wood, paper, clothing, and medicines.

We need plants to feed, clothe, and shelter the human population. All animals owe their existence to plants. If there were no plants, there could be no animals, including mammals like us. It's that simple.

As long as we're talking about plants, can you explain how they have adapted to their environment?

Sure! Most plants are composed of three organs that enable them to adapt to life on land: *roots*, *stems*, and *leaves*.

Roots have three primary functions:

- Absorbing water and minerals
- Anchoring a plant firmly in the ground and providing support
- Producing growth hormones that regulate plant development

The stem provides a supporting framework for the leaves and branches. A plant stem also contains a network of *phloem* and *xylem*. This system of vascular tissue is like a series of tiny pipes that transport water and nutrients throughout a plant, much like the plumbing system in your school.

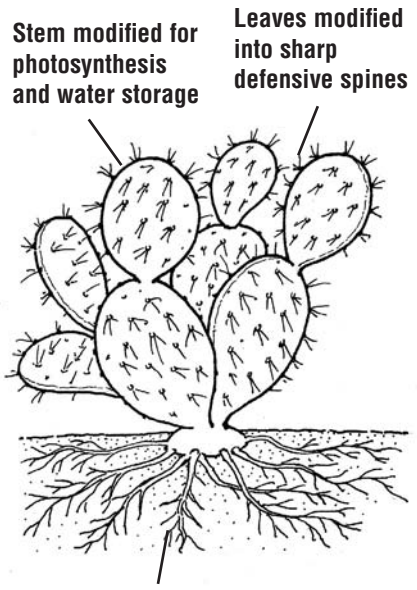
Leaves are the main organs of photosynthesis in plants. They intercept sunlight and capture carbon dioxide from the atmosphere, manufacture food (glucose), and release water vapor and oxygen.

It is important to remember that many plants have evolved specialized roots, stems, and leaves that help the plant adapt to its environment. These include adaptations for protection and defense, water and nutrient storage, the trapping and digesting of insects, and vegetative (asexual) reproduction. The prickly pear cactus is an example of a plant that has evolved a specialized stem and highly modified leaves.

You mentioned phloem and xylem. I have trouble remembering what these words mean. I always seem to mix them up! Can you help?

I used to have trouble with this, too, but I learned a few tricks to help me remember. Phloem is a specialized tissue that carries food (carbohydrates dissolved in water) from the locations where it is made to other cells in the plant. Phloem consists of relatively soft-walled live cells.

Prickly Pear Cactus

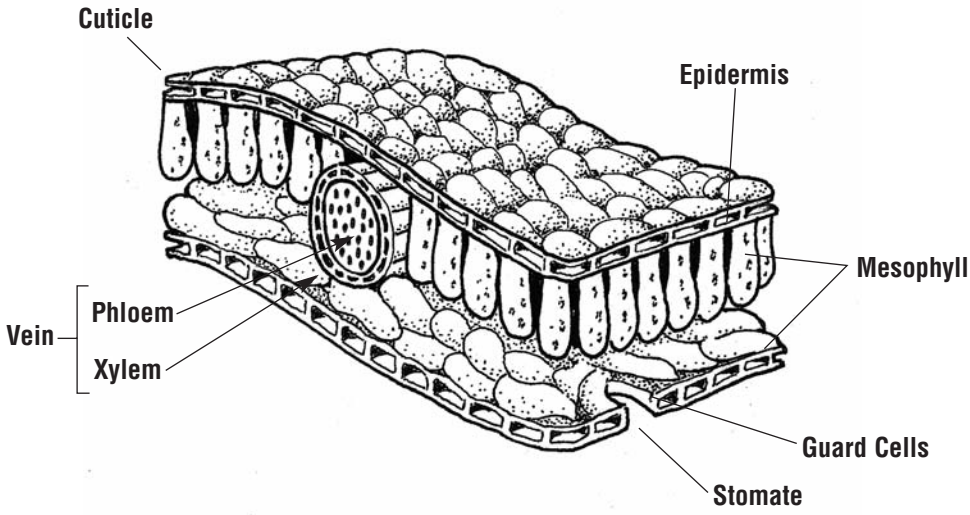


The leaves of the prickly pear cactus have evolved into defensive spines. The jointed stem only resembles true leaves. It is adapted for food production (photosynthesis) and the storage of water and nutrients in a hot, dry environment.

To remember what phloem conducts, just remember what the phloem carries: the plant's food. Phloem and food both start with an F sound.

Xylem is a specialized tissue that carries water and dissolved minerals from the roots to other cells in the plant. Mature xylem consists of hard-walled dead cells.

Leaf Tissue



Did You Know?

Compound light microscopes (like the ones you use in school) are used to observe cells and larger cell structures and organelles. Electron microscopes are used to see viruses, the smallest cell structures, and even large atoms.

So enough about plants. Earlier you mentioned bacteria. Why do I need to know about something I can't even see?

It's true that bacteria are so small that you need a compound light microscope to see them. Viruses are even smaller. Most can't be observed with a compound light microscope.

The last cold that you caught was probably caused by a virus. Viruses cause many serious diseases in humans, such as chicken pox, the flu, measles, AIDS, and certain cancers. Some viruses can even cause birth defects.

Are all viruses bad?

No, most are harmless to humans. In fact, certain viruses have even been used to cure bacterial infections in which the bacteria are resistant to all known antibiotics. So viruses can save the day—I mean, the patient!

Does this mean that bacteria are bad news?

Yes and no. Some bacteria do cause problems for people. You can blame bacteria if you've ever had a tooth cavity or suffered from acne. Bacteria are also responsible for spoiled food. And, of course, bacteria cause many serious human diseases, such as food poisoning, Lyme disease, and strep throat.

What did you mean by "yes and no"?

I'm glad you asked! Most bacteria are actually beneficial.

- Bacteria are important decomposers. They help recycle essential nutrients through the biosphere.
- Helpful bacteria live in the human digestive tract. We couldn't survive without them. These bacteria promote good health and the absorption of nutrients.
- Bacteria are used to produce foods such as yogurt, cheese, and pickles.
- Humans use genetically engineered bacteria to produce drugs such as human insulin.
- Bacteria are also used to make industrial chemicals, harvest metals from ore, treat raw sewage, and clean up polluted water.

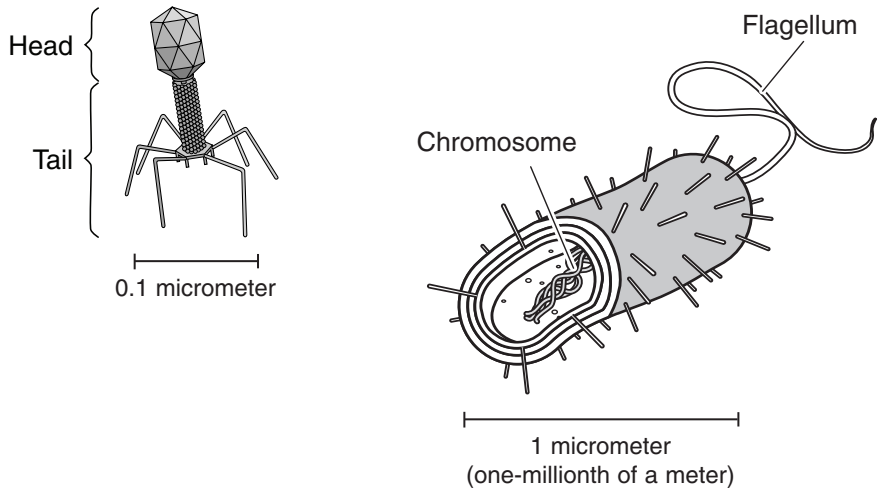
So you see, bacteria really are important. Plant and animal life, including humans, cannot live without Earth's most primitive and abundant life-form.

If viruses and bacteria both cause disease, what makes them different?

Good question. Bacteria are single-celled organisms. Remember, cells are the basic structure of all living things. All cells contain specialized parts that perform specific functions.

Viruses lack the organization and cellular structure that bacteria possess. Viruses cannot reproduce independently; they need a host cell. For these reasons, viruses are not considered living organisms.

Virus Particle **_Salmonella_ Bacterium**

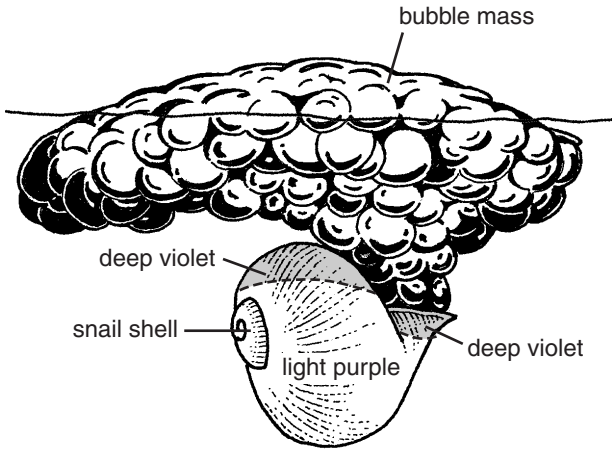


The word *virus* means "poison" in Latin. Viruses are smaller than bacteria. They range in size from 0.005 to 0.35 micrometer.

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose the wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 15



The common purple snail (*Janthina janthina*) feeds on jellyfish. This snail spends its entire life floating upside down in the open ocean, suspended just below the surface by a raft of air bubbles. The shell has a distinctive two-tone violet color. The base, which is directed toward the surface, is deep violet in color. The top, which is directed downward, is a lighter shade of purple. Viewed from above the water's surface, the shell blends in with the dark blue of the deep sea. Viewed from below, the shell is difficult to see against a light-blue sky.

Natural selection has most likely favored the shell color of the common purple snail as a response to —

A predation

B competition

C average water temperature

D jellyfish population density

Answer Key: page 96

Question 16

A person who is taking antibiotics benefits from eating yogurt that contains live and active bacterial cultures because the bacteria in yogurt —

A release enzymes that prevent the reproduction of viruses

B may aid antibiotics by eating harmful bacteria in the human digestive tract

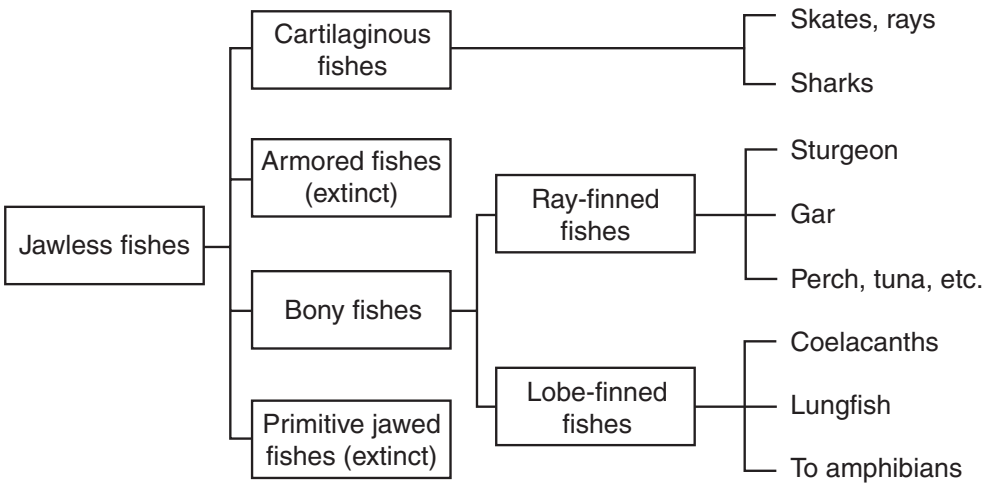
C may restore the normal community of bacteria living in the human digestive tract

D are a major source of dietary fiber, which helps provide the energy needed to fight an infection

Answer Key: page 96

Question 17

Evolutionary History of Jawed Fishes



Which statement about the evolutionary history of jawed fishes is supported by the diagram?

A Jawless fishes became extinct after jawed fishes evolved.

B The first amphibians were direct descendants of lungfish.

C Ray-finned and lobe-finned fishes have a common ancestor.

D Sturgeon are more closely related to sharks than to coelacanths.

Answer Key: page 96

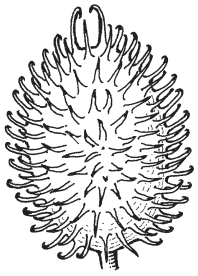
Question 18

Which seed type will most likely be carried by the wind?

A

B

C



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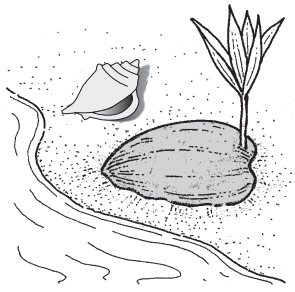


Answer Key: page 97

Question 19

Tropical rain forests support the most-diverse plant communities on Earth. This biome has developed in regions near the equator that are characterized by abundant precipitation and the absence of freezing temperatures. The consistently warm to hot weather and abundant moisture promote rapid chemical weathering and the decay of organic matter. These processes produce thick, nutrient-poor soils.

Plants play a significant role in tropical rain forests by —

A producing thick soils that promote the decay of organic matter

B preventing erosion and allowing nutrients to accumulate in the soil

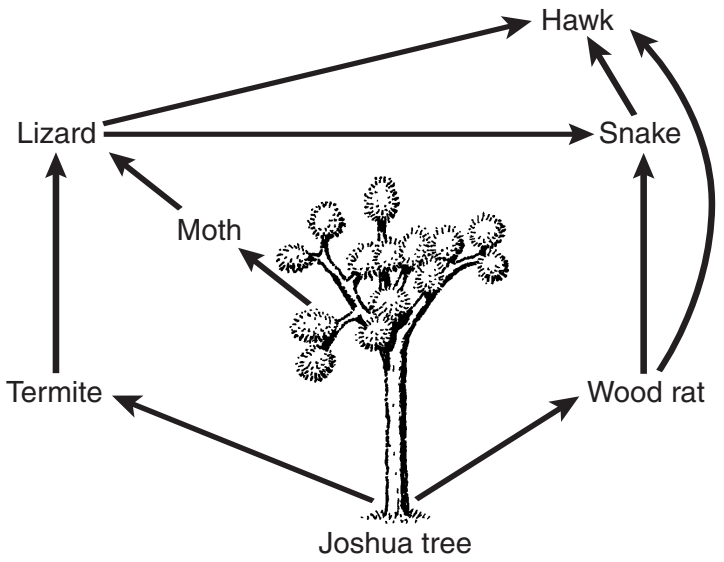
C holding most of the available nutrients within their biomass

D providing insulation and trapping heat that contributes to the high annual temperatures

Answer Key: page 97

Question 20

Partial Desert Food Web: Joshua Tree National Park



Which organisms are both secondary and tertiary consumers in this partial desert food web?

A Hawk and snake

B Lizard and wood rat

C Termite and hawk

D Snake and lizard

Answer Key: page 97

Question 21

Tuberculosis, or TB, is a contagious bacterial disease that usually occurs as an infection of the lungs. The symptoms of this disease include persistent coughing, fever, fatigue, night sweats, and unexplained weight loss. TB can be treated with antibiotics. Tuberculosis is most likely transmitted —

A by mosquito bites

B by blood transfusions

C through the air

D through water

Answer Key: page 97

Objective 4

The student will demonstrate an understanding of the structures and properties of matter.

From your studies in chemistry, you should be able to demonstrate an understanding of the structures and properties of matter.

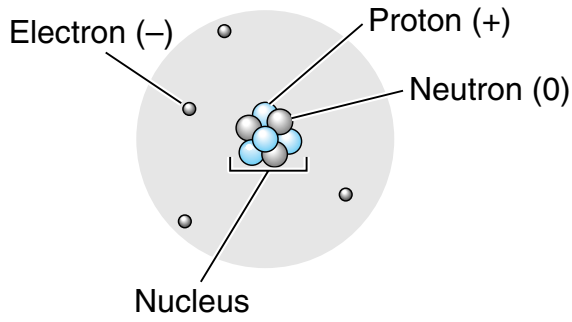
Structures and properties of matter? What's that?

Matter is anything that has mass and takes up space. That includes your pencil, the air you breathe, and even you! All matter is made up of elements or compounds. You need to be able to show that you know what matter is made of and what some of its physical and chemical properties are.

What's an element?

Elements are the building blocks of matter. They cannot be broken down into simpler substances by a chemical reaction. Elements are made up of *atoms*.

Model of an Atom



The nucleus of an atom is made up of positively charged protons and neutral neutrons. A cloud of negatively charged electrons surrounds the nucleus of an atom.

The atoms of different elements have different numbers of protons. For example, all oxygen atoms have eight protons, while all nitrogen atoms have seven. Ninety-two elements exist naturally on Earth, and about twenty more have been made in laboratories.

That's more than 100 different elements! How am I supposed to keep track of all of them?

Lucky for you, scientists came up with the periodic table! The periodic table groups elements with similar properties together. Take a look at the periodic table on page 9 of this book.

What are all those numbers and letters on the periodic table?

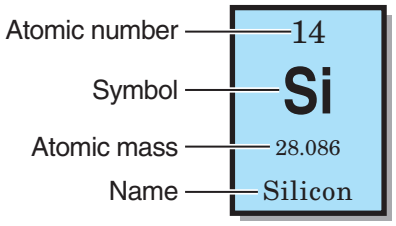
The elements in this periodic table are arranged in order of increasing *atomic number*. The atomic number is equal to the number of protons in each atom of an element. The atomic number is the number listed above the element symbol in each square of this periodic table. For example, this periodic table shows that the atomic number of carbon is 6. Therefore, all carbon atoms have 6 protons.

The periodic table also shows the chemical symbol for each element. The chemical symbol is a one- or two-letter abbreviation. For example, the chemical symbol for carbon is C.

The number listed below the element symbol in each square of this periodic table is the element's *atomic mass*. The atomic mass of an element is the average mass of one atom measured in atomic mass units (amu). An atomic mass unit is approximately equal to the mass of one proton or one neutron.

Did You Know?

Some chemical symbols come from the names of the elements in Latin. For example, the symbol for iron is Fe, from ferrum, the Latin word for "iron."



This diagram shows an example from the periodic table.

The atomic mass of a single atom is approximately equal to the number of protons plus the number of neutrons. So, a nitrogen atom with 7 protons, 7 neutrons, and 7 electrons has an atomic mass of about 14 amu. Because the number of electrons equals the number of protons, the atom as a whole has no charge. Neutrons have no charge and do not affect the charge of the atom.

But how can the periodic table help me make sense of the different elements?

Each column in the periodic table is called a *group*. The elements in each group have similar properties, such as the number of valence electrons. As a result, metals, nonmetals, and metalloids are clustered together in certain parts of the table.

Notice the heavy bold line on the right half of the periodic table. Metals are found on the left side of this line. Metals are usually shiny solids that can be pounded into sheets. They are also good conductors of heat and electricity.

Nonmetals are found on the right side of the heavy bold line on the periodic table. Many nonmetals are gases or liquids under normal conditions. Solid nonmetals are brittle and dull. They are poor conductors of heat and electricity.

Most of the elements that border the heavy bold line are metalloids. Metalloids are located between the metals and nonmetals, and they have properties similar to both groups. Metalloids often act as semiconductors. This means that they normally do not conduct electricity but can be made to do so under certain conditions.

Periodic Table of the Elements

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt									

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

You mentioned valence electrons. What are those?

Much of chemistry is about the movement of electrons. In a chemical reaction, bonds between atoms are formed or broken. These bonds involve the transfer or sharing of electrons between atoms.

Valence electrons are the outermost electrons in the electron cloud surrounding an atom's nucleus. Different elements have different numbers of valence electrons. Because valence electrons are the farthest from the nucleus, they can move from one atom to another much more easily and can participate in bonding.

So how does the periodic table help me figure out how many valence electrons an atom has?

All the elements in some groups of the periodic table have the same number of valence electrons. There is a pattern that can be observed.

Group numbers	1	2	13	14	15	16	17	18
Number of valence electrons	1	2	3	4	5	6	7	8

Elements in Group 1 have one valence electron, and elements in Group 2 have two valence electrons. For Groups 13 through 18, the number of valence electrons is equal to the group number minus 10. The exception to this rule is helium (He). Helium is in Group 18. Helium atoms have only two electrons, so they have two valence electrons rather than eight.

Elements can be solids, liquids, and gases, right?

Yes. A *state of matter* is the form in which a substance exists. *Solid*, *liquid*, and *gas* are states of matter.

The atoms in a solid are packed closely together. As a result, a solid has a definite volume and shape. An iron nail is an example of a solid.

The atoms in a liquid are close together but can flow over one another. A liquid has a definite volume but takes the shape of its container. For example, when you pour water from a pitcher into a glass, the shape of the water changes, but the volume of the water stays the same.

The atoms in a gas are spread apart and can move throughout their container. A gas doesn't have a definite volume or shape. When you pop a balloon, for instance, the air inside it doesn't keep the shape and volume of the balloon. Instead, the air spreads out into the room.

States of Matter

Solid Liquid Gas

The spheres in this diagram represent the atoms of a solid, a liquid, and a gas.

Objective 4

Can substances change state?

Yes! Substances can change from one state of matter to another. For example, when ice is heated to its melting point, it changes from solid ice to liquid water. Similarly, when water is heated to its boiling point, it changes from liquid water to water vapor (a gas).

A change in state is a *physical change*. In a physical change no new substances are produced. Water changes form when it freezes to ice, but water and ice are both H_2O.

Pressure can also affect states of matter. For example, oxygen is a gas under normal conditions, but it can be condensed to a liquid at very high pressures, even if the temperature doesn't change.

What about a chemical change? What's that?

A *chemical change* is one in which new substances are formed. The atoms of the original substances are rearranged to form the new substances. The new substances often have properties that are very different from those of the original substances.

Under certain conditions hydrogen gas and oxygen gas can react to form water. This reaction is a chemical change. The atoms of hydrogen gas and oxygen gas have been rearranged to form water molecules. Water has properties very different from those of either hydrogen or oxygen. For example, water is a liquid at room temperature and normal pressure, but hydrogen and oxygen are both gases under these conditions.

How can I spot a chemical change?

One sign of a chemical change, or chemical reaction, is a change in temperature. Some chemical changes produce heat; others absorb heat from their surroundings. For example, when hydrogen and oxygen gas react to form water, a large amount of heat is produced.

NASA

The exothermic reaction of liquid hydrogen and liquid oxygen is used to help launch a space shuttle.

Another sign of a chemical change is a change in color. When you burn a piece of white paper, the color changes from white to black. Burning is a chemical change.

The production of a *precipitate* or a gas also signals a chemical change. If you mix baking soda and vinegar, for example, gas bubbles are produced. The baking soda and vinegar have reacted to form carbon dioxide gas—a new substance.

Remember!

An exothermic reaction is one that produces heat, and an endothermic reaction is one that absorbs heat.

Remember!

A precipitate is a solid that settles out of a solution as a result of a chemical reaction.

It is important to remember that if you observe only one of these signs, a chemical reaction may not necessarily have taken place. When water boils, for instance, gas bubbles appear in the water, but no chemical change occurs, only a physical change. The only sure sign of a chemical change is the production of a new substance.

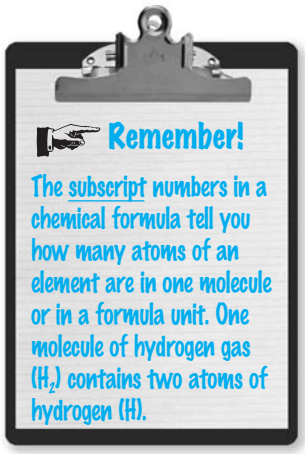
Can you help me with chemical equations?

No problem! A *chemical equation* is a way of writing out what happens during a chemical change. For example, a chemical equation can be used to describe the reaction of hydrogen gas with oxygen gas.

$$H_2 + O_2 \longrightarrow H_2O \quad \text{(unbalanced)}$$

A chemical equation contains a lot of information. The left side of the equation shows what you started with (the reactants). In this example the reactants are hydrogen gas (H_2) and oxygen gas (O_2). The right side of the equation shows what you ended up with (the products). In this example, the product is water (H_2O).

This chemical equation, however, isn't quite finished. To complete the equation, we need to balance it.



Balance it? How do we do that?

When we balance an equation, we make sure that the left side of the equation has the same number and types of atoms as the right side of the equation. We need to balance the equation to show that it follows the law of conservation of mass.

The law of what?

The *law of conservation of mass* states that matter cannot be created or destroyed in a chemical reaction. All the atoms of the reactants in a chemical reaction are still present in the products; they've just been rearranged. We need to balance the equation to show this.

How do we do that exactly?

First let's look at the hydrogen. The left side of the equation has two atoms of hydrogen, and so does the right side, so hydrogen is balanced.

$$H_2 + O_2 \longrightarrow H_2O \quad \text{(unbalanced)}$$

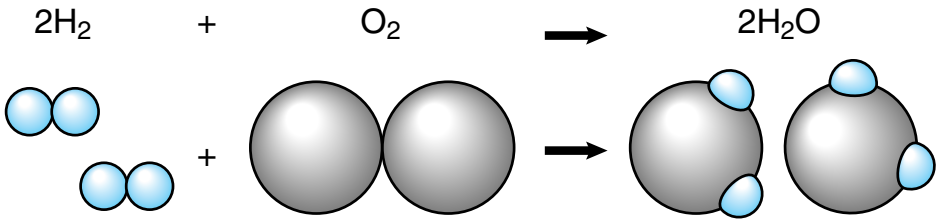
Next look at the oxygen. The left side of the equation has two atoms of oxygen, but the right side has only one atom of oxygen. That means we'll have to add a "2" in front of the "H_2O." This number is called the *coefficient*. When balancing a chemical equation, you should change only the coefficients. The symbol $2H_2O$ means "two molecules of water."

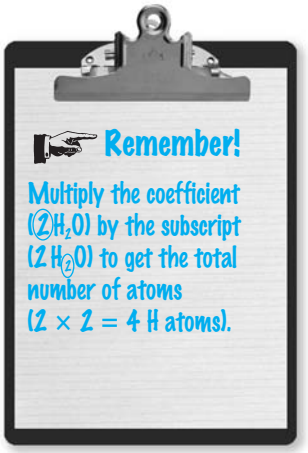
$$H_2 + O_2 \longrightarrow 2H_2O \quad \text{(unbalanced)}$$

subscript coefficient

Oops! Now there are two hydrogen atoms on the left side and four on the right. Let's fix the hydrogen on the left so that the atoms balance.

Recheck to make sure everything follows the law now. The left side of the equation has four hydrogen atoms and two oxygen atoms. So does the right side. Everything balances!





Tell me about solutions. What are they?

A *solution* is a mixture in which one substance dissolves in another. When a substance dissolves, it breaks up into tiny particles that spread evenly throughout the mixture. The substances in a solution are distributed evenly.

A solution has two parts: the *solute* and the *solvent*. The solute is the substance that dissolves, and the solvent is the substance that the solute dissolves in. In a solution of salt water, salt is the solute, and water is the solvent.

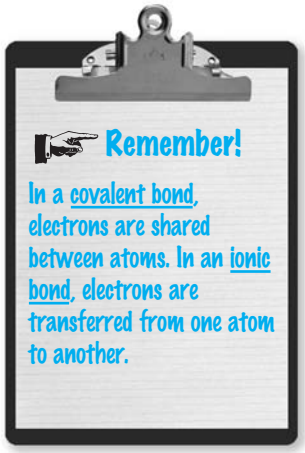
Are all solutions liquids?

No. Many types of solutions are possible. Here are a few examples.

Examples of Solutions

Combinations of States	Solute	Solvent	Example
Gas–Gas	Oxygen and other gases	Nitrogen	Air
Gas–Liquid	Carbon dioxide	Water	Soda water
Liquid–Liquid	Acetic acid	Water	Vinegar
Solid–Liquid	Salt	Water	Salt water
Solid–Solid	Zinc	Copper	Brass

Objective 4

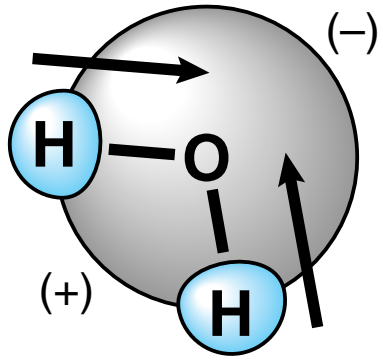


I know that water is a polar solvent. What does that mean?

I'll explain in a minute. But first let me talk about the sharing of electrons in molecules. Atoms on the right side of the periodic table (such as oxygen) tend to pull more strongly on the electrons in a covalent bond than atoms of the left side of the periodic table (such as hydrogen).

In a water molecule the oxygen atom tends to pull the shared electrons away from the hydrogen atoms, so the oxygen end of a water molecule has a partial negative charge and the hydrogen end has a partial positive charge. Molecules with a slightly negative end and a slightly positive end are called *polar molecules*.

Water Molecule



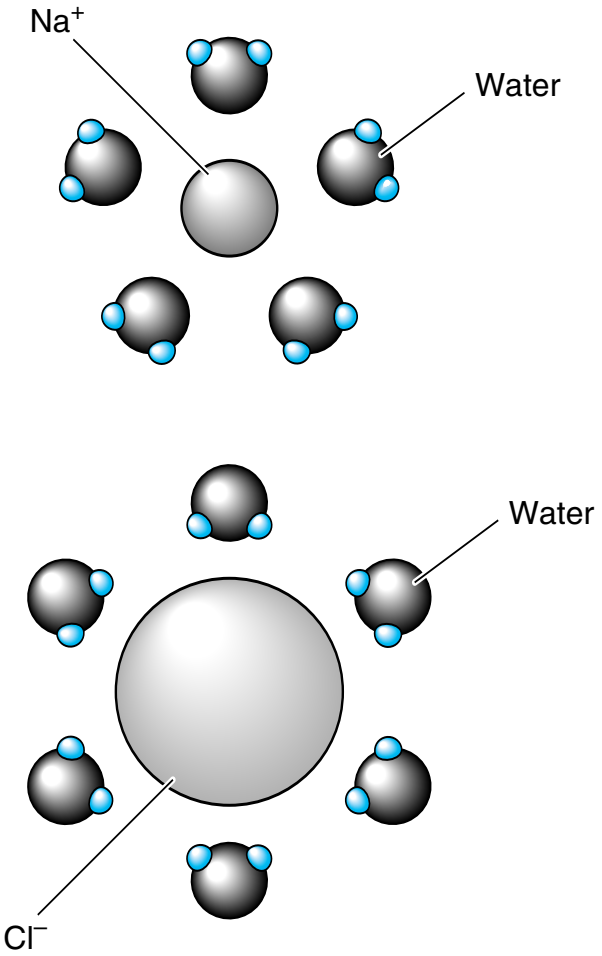
The unequal sharing of electrons in a water molecule gives the molecule a slightly negative end and a slightly positive end.

What does this have to do with water in solutions?

Because water is polar, it tends to dissolve other polar compounds. For example, many ionic compounds dissolve in water. When ionic compounds dissolve, they break up into positive and negative ions.

The negative end of water molecules is attracted to the positive ions, and the positive end of water molecules is attracted to negative ions. Each solute ion becomes surrounded by a "shell" of water molecules. This helps keep the solute ions in solution.

Sodium Chloride Dissolved in Water



When sodium chloride (NaCl) dissolves in water, it breaks up into sodium ions (Na^+) and chloride ions (Cl^-). The negative end of water molecules is attracted to sodium ions, and the positive end of water molecules is attracted to chloride ions.

What are some other properties of water?

Cohesion is another property of water. Cohesion is the tendency of water molecules to stick together. It is caused by the attraction of the positive end of one water molecule for the negative end of another.

To see cohesion in action, gently lay a paper clip on top of a glass of water. As long as you don't break the surface, the paper clip will remain on top of the water. The attraction of the water molecules to one another is strong enough to keep the paper clip from sinking.

Because water molecules are polar, they also have a tendency to stick to other polar substances. This property is called *adhesion*. For example, glass can carry a partial charge along its surface. That's why rain droplets stick to the windshield of a car.

Objective 4

The polar nature of water also causes ice to float. To understand why, you first have to understand density and buoyancy.

O.K., what's density?

Density is a measure of a substance's mass per unit of volume. A really dense object has much more mass in a given space than an object that isn't very dense.

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

For example, aluminum isn't very dense. That's why empty aluminum soda cans don't have much mass. If soda cans were made out of a dense metal, such as gold or lead, they would be much heavier than aluminum cans, even if they were the same size.

Suppose you are going to buy a gold necklace at a discount jeweler. The clerk claims that the necklace is made of pure gold. How could you tell if he is telling the truth? Calculate the density of the necklace and compare it to the density of pure gold.

How do I solve density problems?

You can calculate an object's density by dividing its mass by its volume.

Here's an example. A graduated cylinder containing 20 milliliters of mineral oil has a mass of 98.2 grams. The mass of the empty cylinder is 79.8 grams. What is the density of the mineral oil?

To find the density, we need to know the mass and the volume of the mineral oil. The volume is 20 milliliters. The mass of the oil is equal to the mass of the filled cylinder (98.2 g) minus the mass of the empty cylinder (79.8 g).

$$\begin{aligned}\text{Mass of oil} &= 98.2\text{ g} - 79.8\text{ g} \\ &= 18.4\text{ g}\end{aligned}$$

Now substitute the mass and volume of the oil into the density formula.

$$\begin{aligned}\text{Density} &= \frac{\text{mass}}{\text{volume}} \\ D &= \frac{m}{v} \\ D &= \frac{18.4\text{ g}}{20\text{ mL}} \\ D &= \frac{0.92\text{ g}}{\text{mL}}\end{aligned}$$

So the density of the mineral oil is 0.92 g/mL.

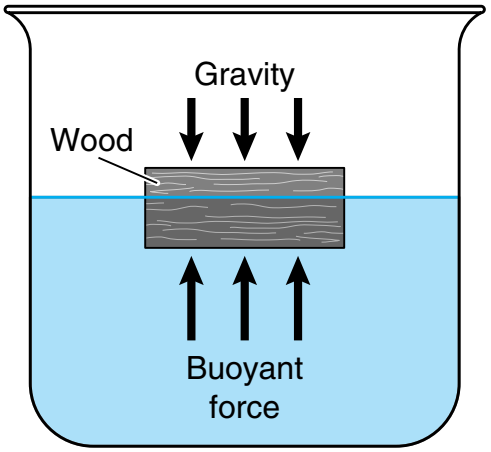
What about buoyancy?

When an object is placed in water, the water exerts a force on all sides of the object. This force increases with depth, so the force at the top of the object is lower than the force at the bottom of the object. This means that the overall direction of the force is upward. This upward force is called the *buoyant force*.

When the buoyant force pushing up on the object is greater than the force of gravity pulling down on the object, the object rises to the surface. If the buoyant force is less than the force of gravity, the object sinks to the bottom.

Did You Know?

The arrows around an object represent vectors. Vectors show the direction of the force. The length of the arrow represents the size of the force.



When wood floats, the buoyant force on the wood is greater than the force of gravity on the wood.

Remember!

The force of gravity on an object is equal to its weight.

How do we know which is greater, the force of gravity or the buoyant force?

We can determine which force is greater by comparing the density of the object to the density of water. If the density of the object is greater than the density of water, the force of gravity on the object will be greater than the buoyant force, and the object will sink.

If the density of the object is less than the density of water, the force of gravity on the object will be less than the buoyant force, and the object will float. For example, wood with a density of 0.4 gram per cubic centimeter will float on water, which has a density of 1.0 gram per cubic centimeter.

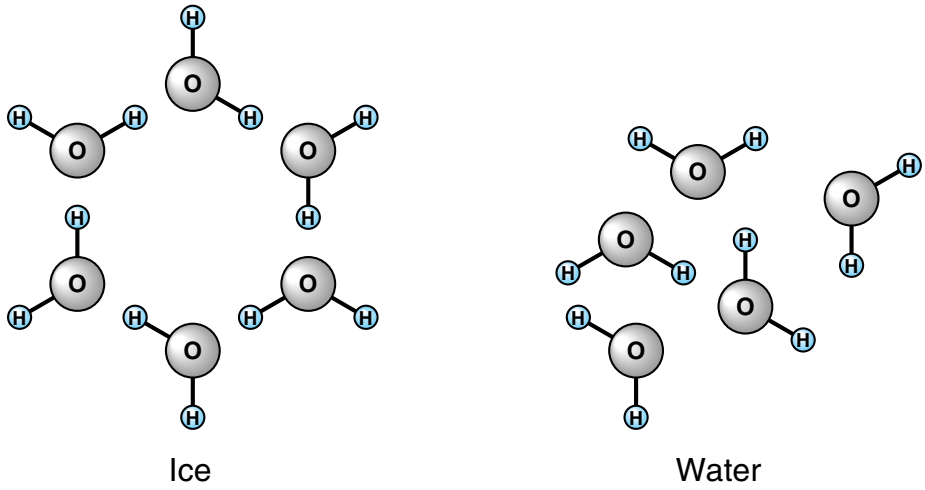
Objective 4

Why does ice float in water? Shouldn't the solid form of water be denser than its liquid form?

When most substances freeze, the molecules making up the substance get closer together. That means that the density of the solid is greater than the density of the liquid form. For example, solid wax is denser than liquid wax, so solid wax would not float on liquid wax.

But water is different. When water freezes, the polar molecules line up, positive to negative, forming a crystal pattern. This pattern causes the molecules to spread apart. This means that ice is less dense than water. Therefore, it floats.

Structure of Ice and Water



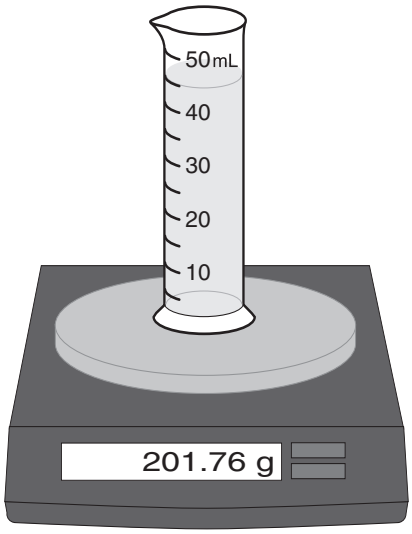
Because ice has a crystalline structure, it has a more orderly arrangement of molecules than liquid water does. This orderly arrangement keeps the molecules in ice from packing together as closely as the molecules in liquid water do.

Because ice is less dense than water, lakes begin to freeze from the top down. The layer of ice that forms on the surface of a lake helps shield the water underneath from cold air temperatures. This tends to keep lakes from freezing solid and killing the organisms that live there.

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose the wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 22



A student measures the mass of an empty graduated cylinder as 87.76 grams. The student then pours a liquid into the cylinder and places it on the scale. According to the student's measurements, what is the density of the liquid in grams per milliliter? Record and bubble in your answer.

				.			
⓪	⓪	⓪	⓪		⓪	⓪	⓪
①	①	①	①		①	①	①
②	②	②	②		②	②	②
③	③	③	③		③	③	③
④	④	④	④		④	④	④
⑤	⑤	⑤	⑤		⑤	⑤	⑤
⑥	⑥	⑥	⑥		⑥	⑥	⑥
⑦	⑦	⑦	⑦		⑦	⑦	⑦
⑧	⑧	⑧	⑧		⑧	⑧	⑧
⑨	⑨	⑨	⑨		⑨	⑨	⑨

Answer Key: page 98

Question 23

Why is a ship with a hollow steel hull able to float in seawater?

A The density of steel is greater than the density of seawater.

B The buoyant force on the ship is less than the weight of the ship.

C The ship displaces a volume of seawater that weighs more than the ship.

D The buoyant force on the ship is less than the weight of the seawater displaced by the ship.

Answer Key: page 98

Question 24

Baking soda consists of the compound sodium bicarbonate ($NaHCO_3$). When baking soda is heated, sodium carbonate (Na_2CO_3) is produced.

Two hundred grams (200 g) of sodium bicarbonate is placed in a test tube and heated with a Bunsen burner. After the reaction is complete, the only substance remaining in the test tube is 126 grams of sodium carbonate. Which best explains why this reaction does not violate the law of conservation of mass?

A Sodium bicarbonate has a greater molecular mass than sodium carbonate.

B The reaction has one or more products that leave the test tube in the form of a gas.

C The high heat of the Bunsen burner destroys some of the atoms in the sodium bicarbonate.

D In the balanced chemical equation, the mass of the reactants is greater than the mass of the products.

Answer Key: page 98

Question 25

A teacher has prepared a saturated solution of potassium nitrate (KNO_3) in 100 grams of water heated to 60°C. About how many grams of potassium nitrate will have settled out of the solution once it reaches a room temperature of 25°C?

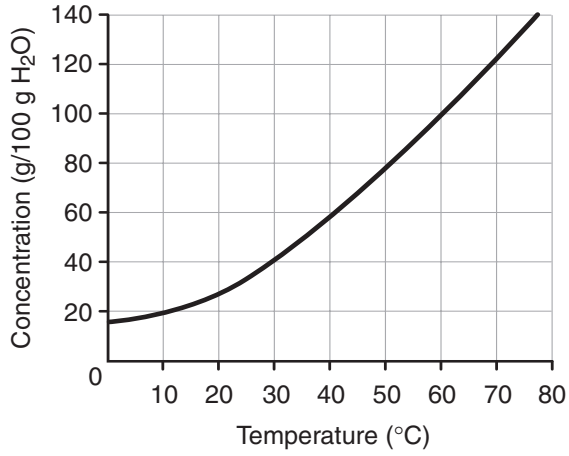
A 30 g

B 65 g

C 95 g

D 145 g

Solubility Curve for Potassium Nitrate

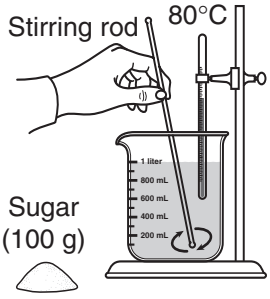


Answer Key: page 99

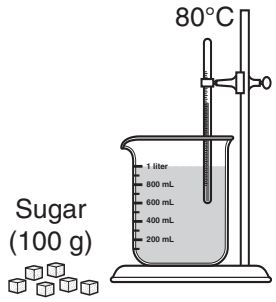
Question 26

Each beaker shown below contains one liter of water. One hundred grams of sugar is added to each beaker. In which beaker will the sugar dissolve the fastest?

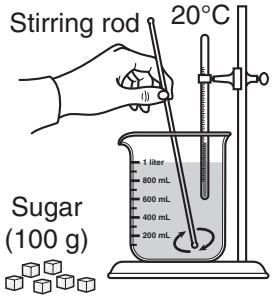
A



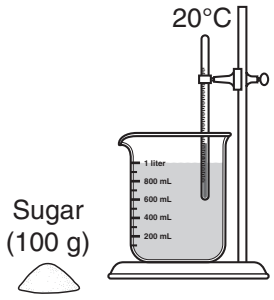
C



B



D



Answer Key: page 99

Question 27

Thermal pollution occurs when human activities cause the temperature of lakes or rivers to rise. Why are fish most likely to be harmed by long-term thermal pollution of the lake in which they live?

A The solubility of oxygen in the lake will decrease.

B The solubility of carbon dioxide in the lake will increase.

C The solubility of potassium fertilizers, such as KCl, will decrease in the lake.

D The solubility of quartz crystals (SiO_2) will increase in the lake.

Answer Key: page 99

Question 28

The unbalanced chemical equation shows the reaction that occurs when a piece of aluminum foil is placed in a solution of water and copper sulfate.

$$\square\ Al(s) + \square\ CuSO_4(aq) \rightarrow \square\ Al_2(SO_4)_3(aq) + \square\ Cu(s)$$

Which set of coefficients balances the chemical equation?

A 1, 3, 1, 3

B 2, 1, 1, 1

C 2, 3, 1, 1

D 2, 3, 1, 3

Answer Key: page 99

Objective 5

The student will demonstrate an understanding of motion, forces, and energy.

From your studies in physics, you should be able to demonstrate an understanding of motion, forces, and energy.

What's so important about motion, forces, and energy?

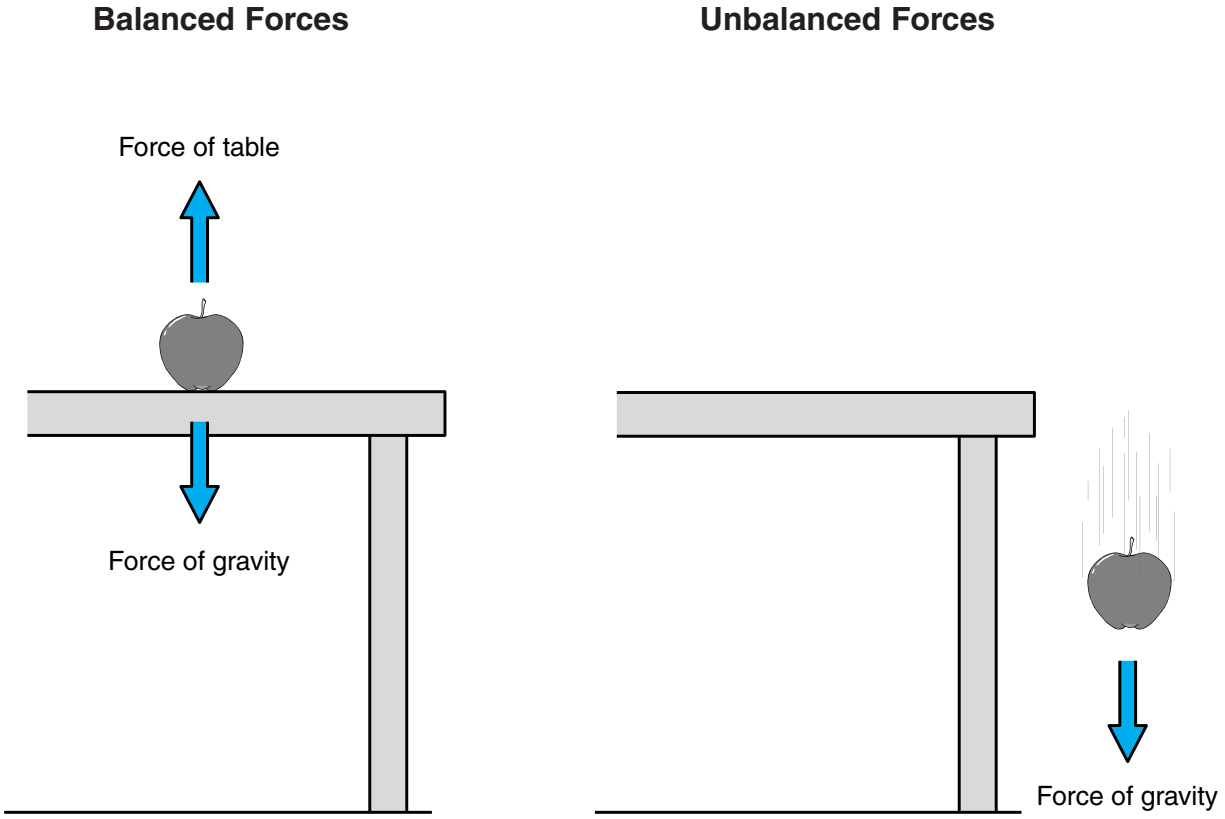
Look around you. What do you see that's moving? A breeze blows across the room. Clouds float across the sky. Even your eyes move to read the words on this page. Physicists use the ideas of force and energy to describe motions in the world around us.

How are motion and forces related?

All motion is caused by forces. We can use forces to explain why things move and to predict how they will move. For instance, a roller-coaster designer needs to understand how forces work to create thrilling rides!

There are often many different forces acting on an object. For instance, when you place an apple on a table, gravity pulls the apple down, but the table holds it up. These two forces balance each other. As a result, the apple stays put.

If you pushed the apple off the table, the force of the table would no longer be there to balance the force of gravity. The unbalanced force of gravity would cause the apple to fall to the ground.



When the forces on the apple are balanced, the apple doesn't move. When the force is unbalanced, the apple falls.

Didn't Isaac Newton have something to do with falling apples?

Yes. Sir Isaac Newton proposed the laws of motion in the seventeenth century. These laws were based on his observations of the world around him. Newton's laws describe how forces and motion are related. Here they are:

Newton's Laws of Motion

- **First Law:** Any object in motion will stay in motion, and any object at rest will stay at rest, until it is acted on by an unbalanced force. This law is also referred to as the law of inertia.
- **Second Law:** The net force on an object equals the object's mass multiplied by its acceleration (Force = mass × acceleration).
- **Third Law:** When one object exerts a force on a second object, the second object exerts an equal but opposite force on the first object.

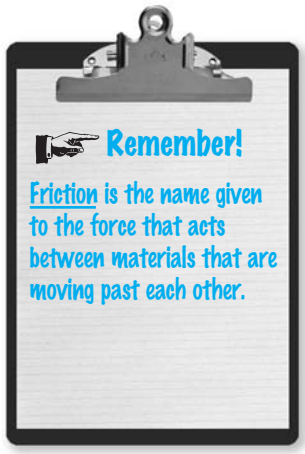
These laws sound a bit complicated at first, but they make sense when you think about them carefully.

Remember!

The overall force on an object is called the net force. An object will move when the net force acting on it is greater than zero.

If I roll a ball across the floor, the ball eventually stops. But Newton's first law says that a moving object should keep moving. How does that make sense?

A ball rolling across the floor does eventually stop. But it doesn't break Newton's first law. To find out why, look more closely at the law. It states that a moving object should keep moving unless there is an unbalanced force on it. There must be a force acting on the ball that causes it to slow down and stop.

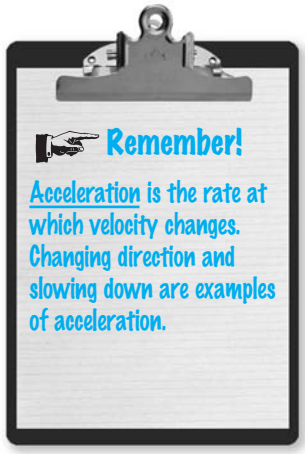


What is that force?

It's friction! *Friction* is an unbalanced force that changes the ball's motion. If there were no friction between the ball and the floor, the ball would keep rolling.

The second law is really just an equation. What's so important about that?

Newton's second law ($F = ma$) is a powerful tool for making predictions about motion. For example, if you know how strong a force is and what size mass it acts on, you can predict how fast an object will accelerate.



How can I understand the second law without using math?

It's easy! First let's look at force and *acceleration*. According to Newton's second law, a greater force produces a greater acceleration. For instance, if you hit a baseball with a bat as hard as you can, it will accelerate more than if you just tap it lightly. The greater the force you exert, the greater the ball's acceleration. That makes sense, right?

We can also think about mass and acceleration. The smaller the mass, the greater the acceleration will be. If you use the same force to throw a bowling ball and a tennis ball, which goes farther? The tennis ball, of course! It accelerates more because it has less mass than the bowling ball.

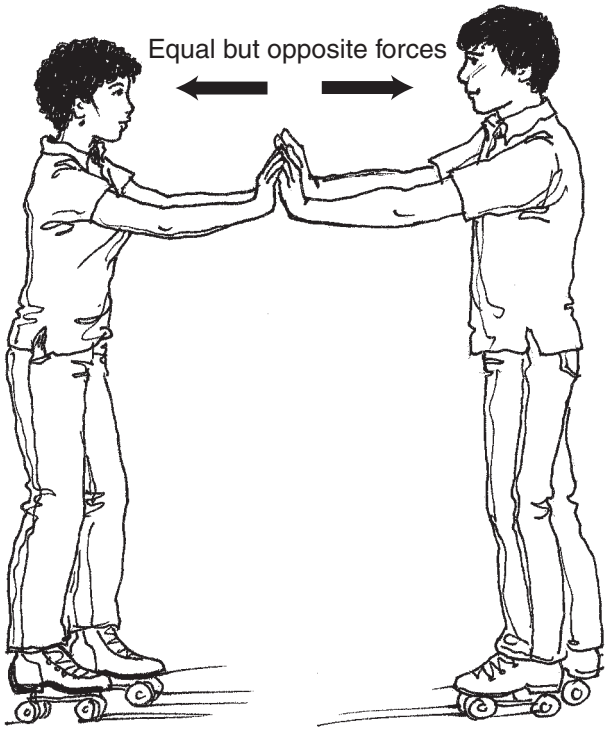
Umm . . . could you explain the third law a bit better?

I'm glad you asked! Newton's third law states that all forces come in pairs. For example, when you bounce a basketball, the ball exerts a force on the floor. The floor also exerts a force back on the ball. That's why the ball bounces. The floor's force on the ball is exactly the same size as the ball's force on the floor. But the two forces act in opposite directions.

Do these pairs of forces cancel each other out?

Good question. You might think that since the forces are equal and opposite, they would cancel each other. Why don't they? Well, they are acting on different objects. In order to cancel each other, two opposite forces must act on the same object.

For example, suppose that you and I are wearing roller skates and facing each other. If I push on you, you will push back on me with an equal but opposite force (even if you aren't aware of it). My force on you will cause you to move backward, and your force on me will cause me to move backward. Even though the forces are equal but opposite, they do not cancel out, because one acts on me and one acts on you.



When one skater pushes on the other, the second skater pushes back with an equal but opposite force. There is a net force on each skater, and each rolls backward.

Objective 5

How do I use the formula chart to solve physics problems?

Many ideas in physics, such as Newton's second law, can be written as formulas. You can use these formulas to solve problems and make predictions. Look at the formula chart located on page 8. To use a formula, you need to know what each variable represents. The words on the left side of the formula chart tell you this. For example, look at this formula.

$$P = \frac{W}{t}$$

The left side of the chart shows that this is the formula for power. P represents power, W represents work, and t represents time.

After the formulas there is a table titled "Constants/Conversions." What are these?

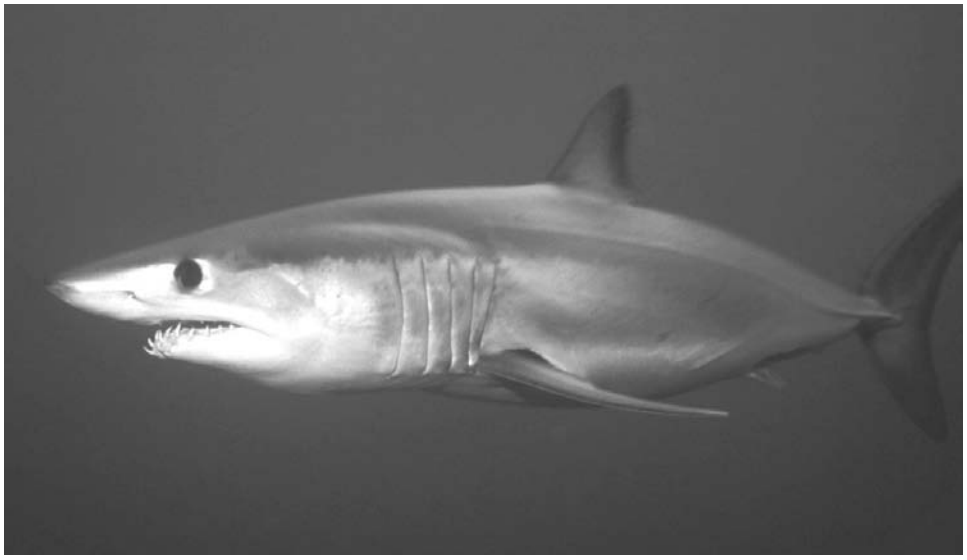
This table gives you extra information you might need to solve problems. For example, constants are values for things that don't change, such as the speed of light (c) or the acceleration due to gravity (g).

The table also shows some common conversions. A conversion shows you how to change from one unit to another. For example, the table shows that 1 newton (N) is equal to 1 kgm/s^2. You can use this conversion to change the answer to a problem from 8 kgm/s^2 to 8 N.

O.K., I think I'm ready to try a force problem. Can you show me how to do one?

I was hoping you would ask that! Mako sharks have a mass of about 450 kilograms. Let's calculate the *weight* of a mako shark in *newtons*. (Calculating the weight is much easier than trying to get a shark onto a scale!)

Mako Shark



First figure out which formula you should use. Let's list what we know and what we want to find out. We don't know much—only the mass of the shark (450 kilograms). We want to find out the weight of the shark. Look at the formula chart on page 8 for a formula that relates weight to mass.

I don't see one! There isn't a formula with weight in it. What do we do now?

Now we think! What is weight? Weight is the force of gravity on an object, so weight is a force. Find the formula that relates force to mass.

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$F = ma$$

Remember this formula? It's Newton's second law of motion!

Next, substitute the values you know and solve for what you want to find out.

Objective 5

Wait a minute! What value are we supposed to use for acceleration?

Remember that weight refers to the force of gravity, so the acceleration we should use is the acceleration due to gravity. This value is listed in the constants/conversions table.

$$g = \text{acceleration due to gravity} = 9.8 \text{ m/s}^2$$

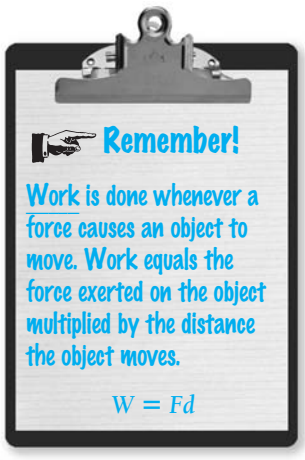
Okay, we know the mass (450 kg). We know the acceleration (9.8 m/s^2). We're ready to use the formula.

$$\text{Force} = \text{mass} \times \text{acceleration}$$
$$F = ma$$
$$F = 450 \text{ kg} \times 9.8 \text{ m/s}^2$$
$$F = 4410 \text{ kgm/s}^2$$

The force of gravity, or the weight, is 4410 kgm/s^2. But we want the weight in newtons. The constants/conversions table shows that 1 newton (N) is equal to 1 kgm/s^2. So, 4410 kgm/s^2 = 4410 N.

Cool! We used math to solve a physics problem! The shark weighs 4410 newtons. Can you show me how to do a two-part problem—one with two formulas?

Sure! Here's a sample problem: A forklift pushes a crate with a mass of 55 kilograms. The crate accelerates at a rate of 0.5 m/s^2. If 209 joules of work is done on the crate, how many meters does the crate move?



First, let's write down what we know and what we want to know.

mass = 55 kg acceleration = 0.5 m/s^2 work = 209 J

distance = ?

Now, look at the formula chart on page 8 to see which equations to use. Which equations include these four variables: mass, acceleration, work, and distance?

The force formula relates mass and acceleration. And the work formula relates work and distance. Can we use these two formulas?

Yes, we can!

$$\text{Force} = \text{mass} \times \text{acceleration} \qquad F = ma$$

$$\text{Work} = \text{force} \times \text{distance} \qquad W = Fd$$

We know the mass and the acceleration, so we can use the first equation to solve for force. Then we can substitute force and work into the second equation and solve for the distance.

Let's *solve the first equation*.

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$F = ma$$

$$F = 55 \text{ kg} \times 0.5 \text{ m/s}^2$$

$$F = 27.5 \text{ kgm/s}^2$$

$$F = 27.5 \text{ N}$$

The force on the crate is 27.5 newtons. We can use this value for force to *solve the second equation*. First, we'll need to get distance on one side of the equation by itself. Divide both sides of the equation by force.

$$\text{Work} = \text{force} \times \text{distance} \qquad W = Fd$$

$$\frac{\text{Work}}{\text{force}} = \text{distance} \qquad \frac{W}{F} = d$$

Now substitute the values we know.

$$\frac{\text{Work}}{\text{force}} = \text{distance}$$

$$\frac{W}{F} = d$$

$$\frac{209 \text{ J}}{27.5 \text{ N}} = d$$

$$\frac{209 \cancel{\text{N}}\text{m}}{27.5 \cancel{\text{N}}} = d$$

$$7.6 \text{ m} = d$$

So the crate moves a distance of 7.6 meters.

Wait! In that second step you changed the work from 209 J to 209 Nm. Why did you do that?

I did that so that we would end up with units of meters. The constants/conversions table shows that 1 joule (J) is equal to 1 newton • meter (Nm).

So 209 J = 209 Nm. When we divide 209 Nm by 27.5 N, the units of newtons cancel, leaving us with units of meters, which is what we wanted.

Can we do one more? How about a momentum problem?

A car has a mass of 900 kilograms. The car travels 600 meters in the same direction for 30 seconds at a constant speed. Let's find the car's *momentum*.

First let's write down what we know and what we want to know.

mass = 900 kg distance = 600 m time = 30 s

momentum = ?

Now, look at the formula chart to see which equations to use. We want to find momentum, so we will probably need to use the momentum formula.

$$\text{Momentum} = \text{mass} \times \text{velocity}$$
$$p = mv$$

We know the mass, but we don't know the velocity. We'll need to calculate the velocity in order to find the momentum.

The only velocity formula in the formula chart is for the velocity of a wave. We need the velocity of a car. What should we do?

Let's think about *velocity*. The velocity of an object is its speed in a particular direction. We know that the car isn't changing direction. We can use speed in place of velocity. And, lucky for us, there's a formula for speed in the formula chart.

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$
$$s = \frac{d}{t}$$

Let's substitute the values we know and solve the equations. First let's find the car's speed.

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$s = \frac{d}{t}$$

$$s = \frac{600 \text{ m}}{30 \text{ s}}$$

$$s = 20 \text{ m/s}$$

The car's speed is 20 m/s. We can use this value for the velocity. Now we're ready to find the momentum.

$$\text{Momentum} = \text{mass} \times \text{velocity}$$

$$p = mv$$

$$p = 900 \text{ kg} \times 20 \text{ m/s}$$

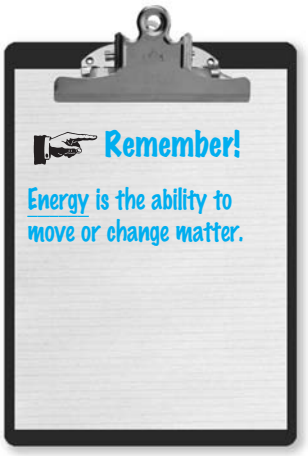
$$p = 18{,}000 \text{ kgm/s}$$

The car's momentum is 18,000 kgm/s.

O.K., enough about motion and forces. What about energy?

Every day you get energy from the food you eat and then use that energy to study, to play sports, or even just to relax. Energy plays a big part in your life.

All moving objects have energy. For example, a roller coaster climbing a steep hill has energy of motion, or *kinetic energy*. An object can also have *potential energy*. A roller coaster sitting at the top of a hill has potential energy because of its height above the ground. This energy is changed into kinetic energy once the roller coaster starts to roll downhill.



What happens to the roller coaster's energy at the end of the ride? Does it just disappear?

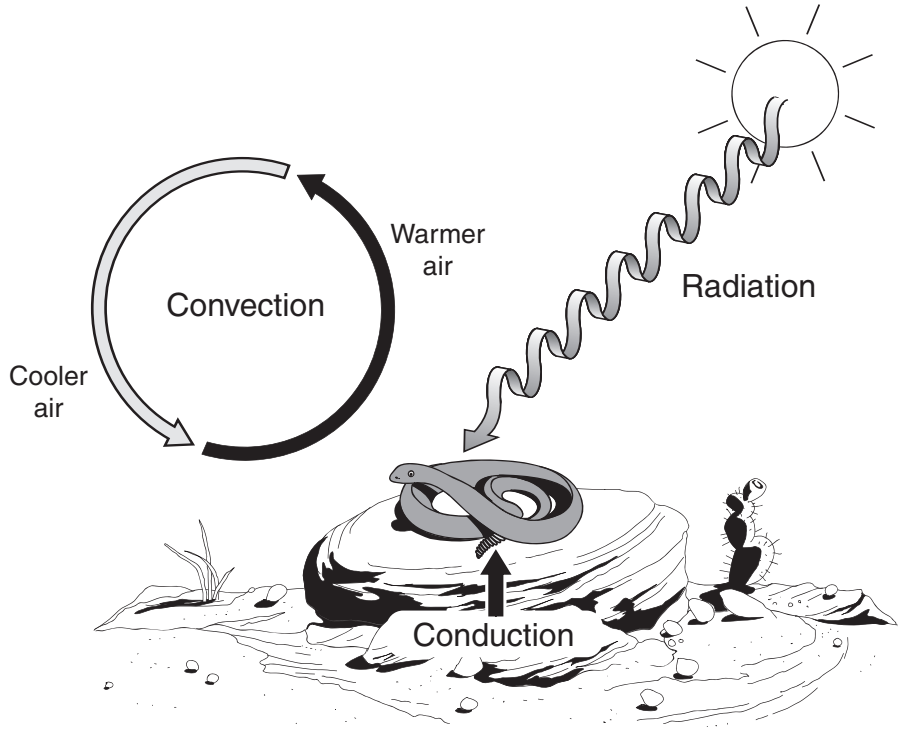
No, it doesn't! It just changes form. The *law of conservation of energy* states that energy is neither created nor destroyed. The roller coaster's energy doesn't disappear; it just changes into a different form when the roller coaster comes to a stop at the end of the ride.

When the roller coaster slows down, the friction between the wheels of the cars and the rails increases. Friction generates heat. The mechanical energy of the roller coaster is changed into heat energy when it comes to a stop at the end of the ride.

How does energy move from one object to another?

Heat energy always moves from a warmer object to a colder object. There are three ways that heat energy can move: radiation, conduction, and convection. Take a look at this snake basking on a rock.

Three Types of Heat Transfer



Solar energy from the sun travels through space in the form of *electromagnetic waves*. This energy is transferred to Earth's surface in the form of heat. Heat transfer by means of electromagnetic waves is called *radiation*. The sun is not the only source of radiant energy. For example, you can also feel radiation by sitting near a fire in a fireplace.

Another type of heat transfer is *conduction*. Conduction is the transfer of heat within an object or between objects that are touching each other. For example, when the snake's rock absorbs heat through radiation from the sun, some of the heat is transferred to the snake by conduction.

The third kind of heat transfer is *convection*. Convection is the transfer of heat by the movement of a current. A current that transfers heat is called a *convection current*. For example, heat from Earth's surface warms the air closest to the ground. Warm air is less dense than cool air, so warm air rises, and cooler air sinks close to the surface. The rising warm air and the sinking cool air together form a convection current. This current transfers heat within the atmosphere.

Remember!

Heat can be transferred through a vacuum only by radiation, not by conduction or convection.

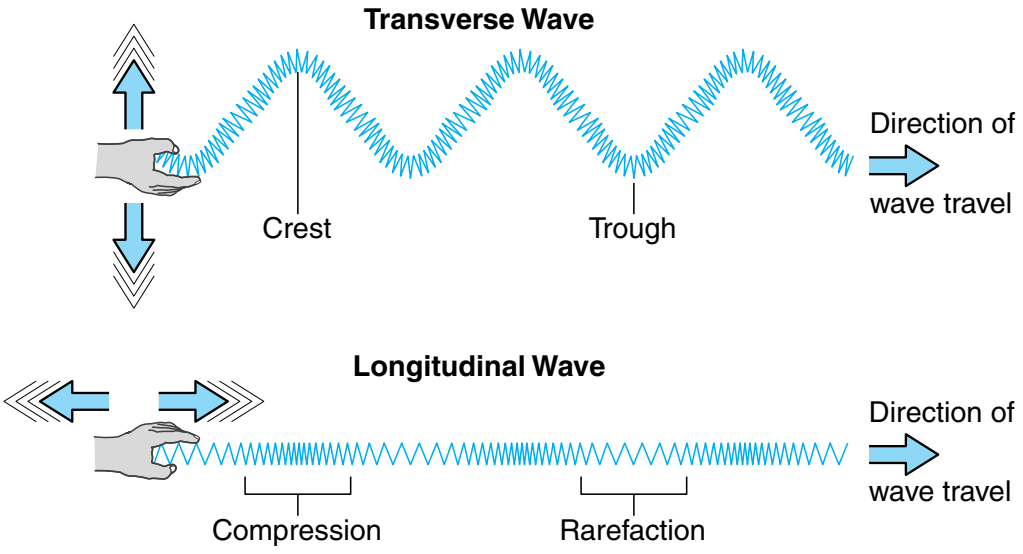
O.K., now I know how heat moves. How about waves? How do they travel?

A *wave* is a disturbance that transfers energy from one place to another. All waves are produced by some kind of vibration. In a *transverse wave* the vibration is perpendicular to the direction in which the wave travels. For example, if a transverse wave travels from left to right, the medium vibrates up and down.

In a *longitudinal wave* the vibration of the wave is parallel to the direction in which the wave travels. If a longitudinal wave travels from left to right, the medium vibrates left and right as well.

Remember!

A medium such as air or water is the material or matter through which a wave travels.



Both waves travel from left to right. But in a transverse wave the medium vibrates up and down, and in a longitudinal wave the medium vibrates back and forth.

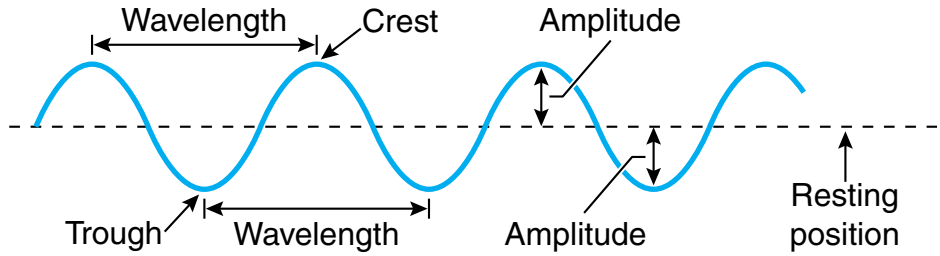
Objective 5

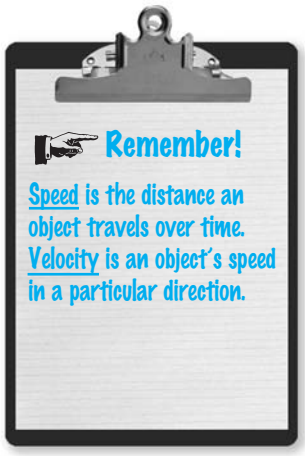
How do scientists measure waves?

Scientists measure waves by describing their properties. Some of the properties of waves are *wavelength*, *amplitude*, *speed*, and *frequency*.

Take a look at the transverse wave below. The wavelength is the distance from one crest (or high point) to the next or from one trough (or low point) to the next. Because wavelength is a distance, it can be measured in meters (m).

The amplitude of the wave is the distance from the resting position to a crest or from the resting position to a trough. Amplitude can also be measured in meters.





The greater the amplitude of a wave, the more energy the wave transfers. If you think about it, this makes sense. A huge ocean wave has a much larger amplitude than a tiny ripple. It also has more energy. A tiny ripple doesn't have enough energy to knock you off a surfboard, but a huge ocean wave might!

What's the difference between speed and frequency?

The speed of a wave is the distance the wave travels in one unit of time. So the speed of a wave can be measured in units of meters per second (m/s).

To measure frequency, you need to figure out how many wavelengths pass a particular point in one unit of time. Frequency is measured in units called *hertz* (Hz). One hertz is equal to 1 wave per second. For example, if 3 complete wavelengths pass you every second, the frequency is 3 waves per second or 3 hertz.

What about electromagnetic waves? What are they?

Electromagnetic waves include radio waves, microwaves, infrared waves, visible light, ultraviolet rays, and X rays. Without electromagnetic waves, you wouldn't be able to listen to the radio, watch television, use a microwave oven, or even look at a sunset.

Electromagnetic waves are different from other waves because they can travel through a vacuum like space. They don't require a medium as other waves do.

All electromagnetic waves travel through a vacuum at the same speed. This constant speed is often called the *speed of light*. The speed of light is equal to 3×10^8 meters per second.

Wait a minute. Isn't there a formula about waves on the formula chart? How do I use it?

The formula chart tells you that the velocity of a wave equals its frequency times its wavelength. Suppose a radio station broadcasts radio waves at a frequency of 1.021×10^8 hertz. Let's find the wavelength of the waves.

We already know which formula we want to use—the one that relates frequency to wavelength.

$$\text{Velocity of a wave} = \text{frequency} \times \text{wavelength} \qquad v = f\lambda$$

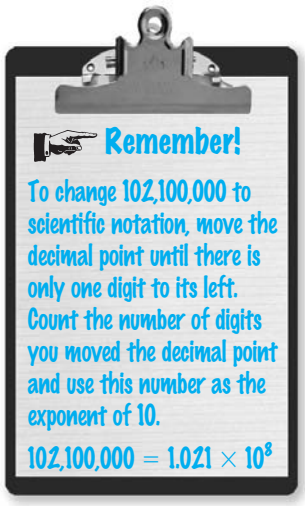
Let's rearrange this formula so that we can solve for wavelength. Divide both sides of the equation by frequency.

$$\frac{\text{velocity of a wave}}{\text{frequency}} = \text{wavelength} \qquad \frac{v}{f} = \lambda$$

Objective 5

But we don't know the velocity of the wave. How can we solve for the wavelength without the velocity?

Hmm . . . let's think. We're talking about radio waves. Radio waves are electromagnetic waves, and electromagnetic waves travel at the speed of light. Because we don't care what direction the waves are traveling, we can substitute the speed of the waves for the velocity. (Remember that velocity is speed in a particular direction.) The constants/conversions chart tells us that the speed of light is 3×10^8 m/s.



Let's substitute the values we know into the formula and solve for wavelength.

$$\text{wavelength} = \frac{\text{velocity of a wave}}{\text{frequency}}$$

$$\lambda = \frac{v}{f}$$

$$\lambda = \frac{3 \times 10^8 \text{ m/s}}{1.021 \times 10^8 \text{ Hz}}$$

$$\lambda = \frac{300{,}000{,}000 \text{ m/s}}{102{,}100{,}000 \text{ Hz}}$$

$$\lambda = 2.938 \text{ m}$$

The wavelength of the radio waves is 2.938 meters.

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose the wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 29

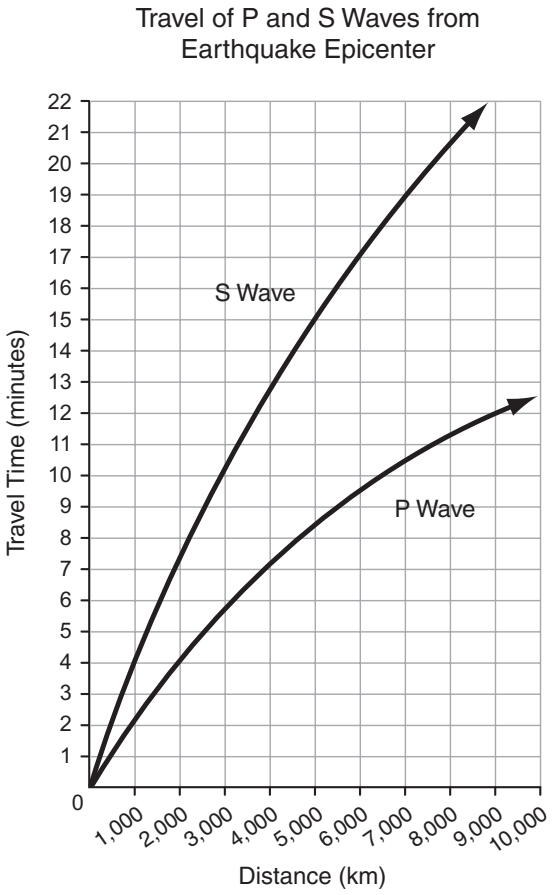
During an earthquake, primary (P) waves travel faster than secondary (S) waves. The difference in arrival time between a P wave and an S wave can be used to determine the distance from a seismograph to the epicenter of the earthquake. A seismograph station records the first P wave of an earthquake at 05:26:00 (hour:minute:second). If the epicenter of the earthquake is 4,000 kilometers from the station, at what time will the station record the first S wave?

A 05:20:30

B 05:30:00

C 05:31:30

D 05:38:30



Answer Key: page 100

Question 30

It takes a weight lifter 4.0 seconds to lift a barbell 1.5 meters. He exerts a force on the barbell of 1500 newtons. About how much power does the weight lifter use to lift the barbell?

A 375 watts

B 563 watts

C 2250 watts

D 9000 watts

Answer Key: page 100

Question 31

During a test of vehicle safety standards, four different vehicles were driven at a test wall at 35 km/h. Which vehicle would most likely hit the wall with the greatest force?

A A bicycle

B A motorcycle

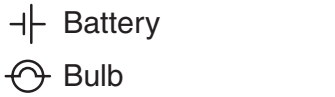
C A two-door sports car

D A four-door family car

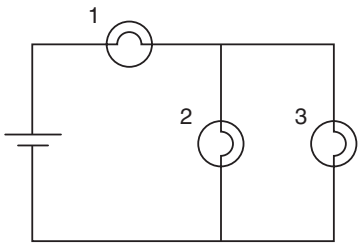
Answer Key: page 100

Question 32

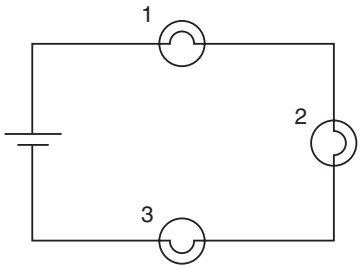
In which circuit will Bulb 3 remain lit if Bulb 1 burns out?



A



B



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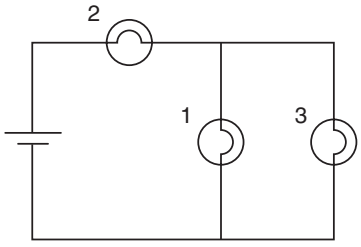

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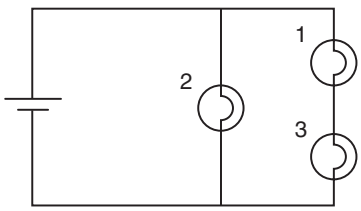
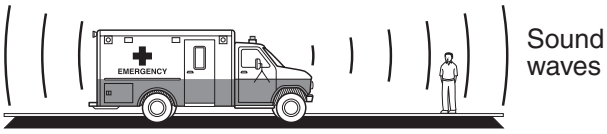


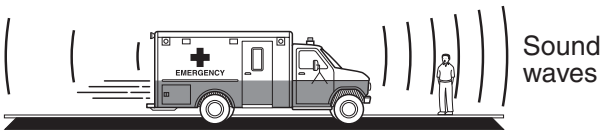
Answer Key: page 100

Question 33

A man standing at a bus stop hears the siren of a parked ambulance. As the ambulance begins moving toward the bus stop, the man hears a change in the sound of the siren.



Parked ambulance



Approaching ambulance

How do the characteristics of the sound waves change as the ambulance begins moving toward the man?

A The amplitude of the waves increases.

B The wavelength of the waves increases.

C The velocity of the waves increases.

D The frequency increases.

Answer Key: page 100

Question 34

A stone is dropped from a bridge and hits the river beneath the bridge 2.30 seconds later. Ignoring the effect of air resistance, what is the stone's approximate velocity when it hits the river?

A 0.235 m/s

B 4.26 m/s

C 12.1 m/s

D 22.5 m/s

Answer Key: page 101

Question 35

In which of the following is the greatest amount of work done?

A Pushing a crate 9.8 meters with a force of 10 newtons

B Pulling a wagon 5.2 meters with a force of 50 newtons

C Pulling a sled 2.3 meters with a force of 90 newtons

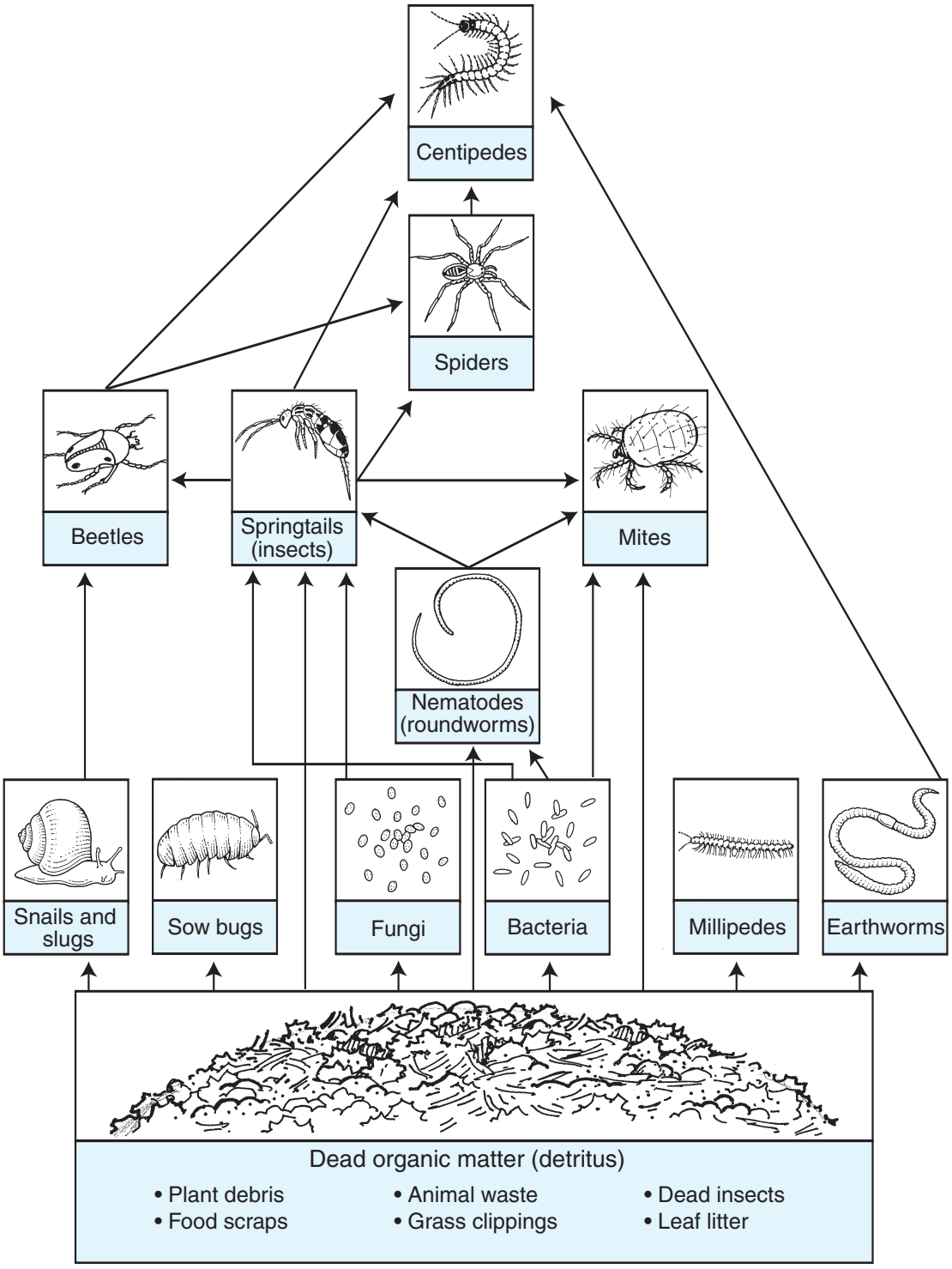
D Pushing with a force of 150 newtons on a car that does not move

Answer Key: page 101

Cluster 1

Use the information below and your knowledge of science to help you answer questions 36–39.

Partial Compost-Pile Food Web



Note: Organisms not drawn to scale

Question 36

Starting in June, a student observed the animals in a compost pile over a period of one year. In September the student removed as many centipedes from the compost pile as she could find and released them in a park several miles away. At the end of one year, there were many more spiders in the compost pile than had been present the year before. There were also fewer springtails and beetles.

Which statement best explains why the populations of springtails and beetles decreased?

A They had less food available to them.

B They had less space available to them.

C They faced increased predation by carnivores.

D They faced increased competition from herbivores.

Answer Key: page 101

Question 37

A group of students set up two compost piles (A and B) that each contain the same amount and type of dead organic material. Both piles are sheltered from precipitation. Twice a week the students add water to Compost Pile A but add no water to Compost Pile B. Once a week the students estimate the numbers of different types of organisms in each pile by random sampling.

Which question are the students most likely trying to answer?

A How does the moisture level in a compost pile change over time?

B What types of organic material lead to the most-diverse compost-pile food webs?

C Do more organisms live in compost piles with moist environments or dry environments?

D How does the number of carnivores in a compost pile affect the number of omnivores?

Answer Key: page 101

Question 38

A chloroplast is an organelle that absorbs sunlight and uses it to produce sugars. Which part of the compost pile is made up of cells that contain chloroplasts?

A Fungi

B Bacteria

C Sow bugs

D Grass clippings

Answer Key: page 101

Question 39

A gardener lifts a bag filled with compost. If the bag has a mass of 36 kilograms, what is the minimum amount of work the gardener must do to lift the bag to a height of 0.5 meter?

A 36.5 J

B 72.0 J

C 176.4 J

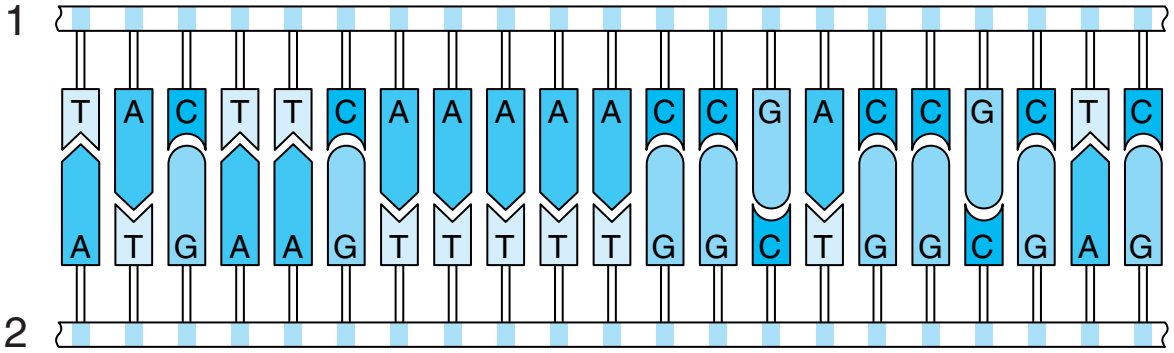
D 352.8 J

Answer Key: page 102

Cluster 2

Use the information below and your knowledge of science to answer questions 40–42.

The following diagram represents a small section of DNA. In this diagram the letters T, C, A, and G stand for the nitrogen bases thymine, cytosine, adenine, and guanine. The codon chart below shows which mRNA codons code for which amino acids. For example, UUU = Phe means that the codon UUU codes for the amino acid abbreviated Phe. The letters U, C, A, and G stand for the nitrogen bases uracil, cytosine, adenine, and guanine.



mRNA Codon Chart

Second Base

First Base	U	C	A	G	Third Base
U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA (Stop) UAG (Stop)	UGU Cys UGC Cys UGA (Stop) UGG Trp	U C A G
C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg	U C A G
A	AUU Iso AUC Iso AUA Iso AUG Met (Start)	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg	U C A G
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly	U C A G

Question 40

Which amino acid chain could be translated from the Strand 1 section of DNA shown in the diagram?

A Arg—Arg—Ala—Gly

B Met—Lys—Phe—Leu—Ala—Gly—Glu

C Thr—Lys—Asn—Arg—Pro—Asp

D Met—Phe—Lys—Asn—Arg—Pro—Iso

Answer Key: page 102

Question 41

A plant has a change in its DNA that makes it more resistant to a species of harmful bacteria. What will most likely happen as a result of this mutation?

A The plant will not survive long enough to reproduce.

B The species of harmful bacteria will become extinct.

C Over time the number of resistant plants will increase.

D Over time the number of harmful bacteria will increase.

Answer Key: page 102

Question 42

Amino Acid Solubilities at Various Temperatures

	Solubility in 100 Grams of Water		
Amino Acid	**0°C**	**25°C**	**50°C**
Alanine	12.11	16.72	23.09
Aspartic acid	0.262	0.778	2.000
Isoleucine	1.826	2.229	3.034
Leucine	0.797	0.991	1.406
Phenylalanine	0.997	1.411	2.187
Serine	2.204	5.023	10.34

Based on the data in the table, which statement best describes the solubility of amino acids?

A Amino acids become less soluble as solvent temperature increases.

B Aspartic acid is the least soluble amino acid at all solvent temperatures.

C Temperature has a greater effect on the solubility of serine than on any other amino acid.

D The solubility of amino acids increases as the temperature of the solvent increases.

Answer Key: page 102

Science Activity

The Floating Rubber Band: A Scientific Trick

Fill a glass with water and drop in a thick rubber band. You'll see that the rubber band sinks to the bottom of the glass. The mass of the rubber band is less than the mass of the water, so why doesn't the rubber band float?

Density is a measure of an object's mass per unit of volume. If an object is less dense than a liquid, it will float in the liquid. If it is denser than the liquid, it will sink. So a rubber band sinks because it has a greater density than water. In other words, 1 cubic centimeter (cm^3) of rubber has a greater mass than 1 cm^3 of water.

Even though you can't make a rubber band float on water, you can still make it float. To do so, you need to make a density column.

Liquid Rainbow

Gather the materials in the following list:

- Small glass or clear plastic cup
- Thick rubber band
- Scissors
- Water
- Cooking oil
- Heavy syrup, such as pancake syrup or corn syrup (You can also use honey or molasses.)
- Small bowl
- Optional: food coloring, spoon, and ruler

Tip: You can still make a density column even if you don't have food coloring. Adding food coloring to the water simply makes it easier to see the different layers in the density column.

Pour a small amount of water into a bowl and stir in a drop or two of food coloring. Slowly pour the water into the glass until the height of the water in the glass is about 2 centimeters.

Empty the bowl and pour in a small amount of cooking oil. Then slowly pour the oil into the glass until the total height of the liquid in the glass is about 4 centimeters.

Did the oil mix with the water, or did it stay in a separate layer? If the oil stayed in its own layer, did it sink or float on water? _____

_____

Empty the bowl again and pour in a small amount of syrup. Slowly pour the syrup into the glass until the total height of the liquid in the glass is about 6 centimeters.

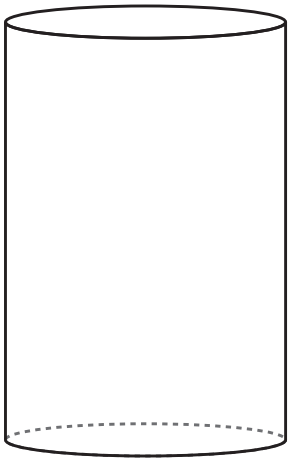
Describe what happened when you added the syrup to the glass.

_____

_____

Floating Layers

Sketch your density column below. Label each of the layers.



Did the liquids mix together? Why or why not? _____

_____

_____

What determines the order of the liquid layers in the glass? _____

_____

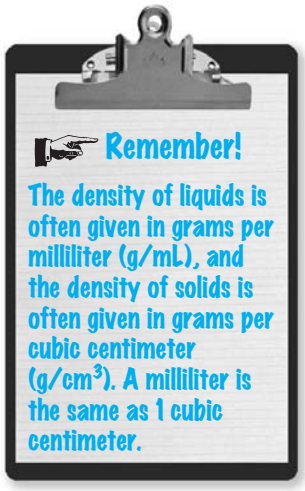
_____

List the liquids in order from least dense to most dense._____

_____

_____

Science Activity



Seeing Is Believing

An object's density can be calculated by dividing its mass by its volume.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \qquad D = \frac{m}{v}$$

You can use this formula to calculate the density of the liquids you used in your density column. Since you probably don't have a graduated cylinder or a balance at home, you can't accurately measure the mass and volume of the liquids yourself. Some sample data are listed in the table below. Use these data to calculate the density of the liquids.

Liquid	Mass (g)	Volume (mL)	Density
Water	30.0	30.0	
Cooking oil	27.6	30.0	
Syrup	41.4	30.0	

Hint:

If a solid floats at the boundary between two liquids, its density is between that of the two liquids.

Based on your calculations, list the liquids in the table in order from least dense to most dense. _____

_____

Does this list agree with what you observed in your density column? Explain. _____

_____

Gather Some Solid Evidence

Use a pair of scissors to cut a piece of rubber band about 2 centimeters in length. Drop the piece into your density column.

What happens when you drop the rubber band into your density column? What does the position of the rubber band tell you about its density?

_____

_____

Try dropping some or all of the following solids into your density column:

- A penny
- A paper clip
- A small ice cube
- A plastic ring from the top of a soda or juice bottle
- Small pieces of butter, candle wax, chocolate, and charcoal
- A wooden toothpick
  (If necessary, break it in half so that it will fit in your glass.)
- Any other small objects you want to test

Use the diagram on page 89 to sketch the position of each object you added to your density column. Label the objects.

List the solids and liquids in your density column in order from least dense to most dense. Note: If two solids float at the same level, you will not be able to tell which one is denser than the other. In this case, list the two objects next to each other and circle them.

_____

_____

If you like, try adding other liquids to your density column. However, don't add household cleaners such as bleach and ammonia to your density column. These cleaners could give off hazardous fumes if mixed together.

Be aware that if you add a liquid that is soluble in one of the liquids already in your column, the new liquid may not form its own layer. Instead, it may dissolve in one of the existing layers. Some other liquids to try include baby oil, liquid dish soap, rubbing alcohol, and mouthwash.

Safety Tip:

Don't add household cleaners such as bleach and ammonia to your density column. These cleaners could give off hazardous fumes if mixed together.

Science Activity

A Legendary Mystery

Archimedes was a mathematician and scientist who lived in ancient Greece. According to legend, Archimedes used his understanding of density to solve a crime. The king of Syracuse had received a new crown. The crown was supposed to be made of pure gold, but the king suspected that the gold had been mixed with silver.

Archimedes measured the density of the crown and found that it was less dense than pure gold. This evidence revealed that the king had been cheated by his crown maker. The gold in the crown had indeed been mixed with a lighter metal.

Suppose an archaeologist unearths a coin from the buried ruins of an ancient city. The coin has a mass of 4.18 grams and a volume of 0.23 cm^3. Find the density of the coin. Show your work in the space below.

The density of gold is 19.3 g/cm^3. Is the coin found by the archaeologist made of pure gold? Explain. _____

_____

Look at the sample results on page 103 to see how your answers compare.

Science Answer Key

Objective 1

Question 1 (page 20)

A Incorrect. Study the illustration again. Those plants growing in direct sunlight near the tree are larger than the smaller plants growing in the shade. If drier soil is a limiting factor, all the plants growing near the tree should be smaller.

B Incorrect. Study the illustration again. Those plants growing in direct sunlight near the tree are larger than the smaller plants growing in the shade. If the availability of minerals is a limiting factor, all the plants growing near the tree should be smaller.

C Correct. Only those plants growing in the shade are smaller. It is a reasonable hypothesis that the lower light level in the shaded area is limiting the growth of this plant species.

D Incorrect. Shaded soil will have a lower temperature than soil in direct sunlight. It is unlikely that slight temperature variations over a small distance would have a significant effect on plant growth.

Question 2 (page 20)

A Incorrect. On Day 12, some *P. caudatum* still exist in the culture medium.

B Incorrect. Given the slope of the graph, a small number of *P. caudatum* will still exist in the culture medium on Day 13.

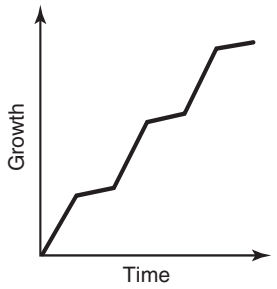
C Correct. The population of *P. caudatum* should reach zero on Day 16 if the slope of the plotted line remains the same as between Days 6 and 12.

D Incorrect. According to the graph, the rate of decline of the population of *P. caudatum* is too great for them to survive to Day 18.

Question 3 (page 21)

A Incorrect. This graph indicates that the rate of growth is constant over time.

B Correct. This graph shows discontinuous intervals of rapid growth (after molting) followed by intervals of slow growth (after development of a new exoskeleton).



C Incorrect. This graph indicates that the rate of growth increases over time.

D Incorrect. This graph shows an initial period of growth followed by alternating periods of no growth (horizontal segments on the graph) and instantaneous growth (vertical segments). It takes time for any organism to grow, so the graph depicts an impossible relationship.

Question 4 (page 21)

A Incorrect. The graph shows that the rate of photosynthesis is significantly lower at 12˚C than at 35˚C.

B Incorrect. The graph shows that the rate of photosynthesis increases with increasing light intensity until it reaches a maximum value.

C Correct. The graph shows that after reaching a maximum value, the rate of photosynthesis begins to decrease as light intensity continues to increase.

D Incorrect. The rate of photosynthesis at 35˚C is higher than the rate at 12˚C for all light intensities shown on the graph.

Question 5 (page 22)

A, B, D Incorrect. These hypotheses can be tested with a well-designed experiment that uses a scientific approach.

C Correct. Opinions based on personal values, aesthetics, or other human preferences or prejudices cannot be tested by scientific methods.

Question 6 (page 22)

A Incorrect. A single serving of this fruit juice contains 29 grams of carbohydrates. A single serving provides only 10 percent of the total daily requirement for carbohydrates in a 2000-Calorie diet.

B Correct. The label states that one serving of this fruit juice provides 10 percent of the total daily requirement for carbohydrates in a 2000-Calorie diet:

$$29 \text{ g} \times 10 = 290 \text{ g (100 percent)}$$

C Incorrect. A single serving of this fruit juice contains 20 milligrams of sodium. Look for the phrase "Total Carbohydrate" on the nutrition label.

D Incorrect. A single serving of this fruit juice contains 350 milligrams of potassium. Look for the phrase "Total Carbohydrate" on the nutrition label.

Question 7 (page 23)

A, B, D Incorrect. These nonprescription medicines do not contain aspirin or other salicylate compounds.

C Correct. Bismuth subsalicylate is a salicylate compound. It is an active ingredient found in nausea medications. This compound should be avoided during recovery from a viral infection.

Objective 2

Question 8 (page 36)

A Incorrect. If a patient were given pure water intravenously, the concentration of water outside cells would increase relative to the concentration of water inside cells. Therefore, water would tend to move into cells and cause cells to swell rather than shrivel.

B Incorrect. Osmosis refers only to the movement of water, not to the movement of salt or other dissolved substances.

C Incorrect. If a patient were given pure water, the concentration of dissolved substances in the fluid outside cells would decrease. This would cause water to move into cells and cause the cells to swell and burst.

D Correct. The fluid inside and outside cells is not pure water; it contains dissolved substances such as salts and sugars. To prevent cells from shriveling or swelling because of osmosis, it is best to give a patient an intravenous solution with a concentration of dissolved substances that is close to the concentration of dissolved substances in the body's fluids.

Question 9 (page 36)

A Correct. As the athlete's heart rate increases, the rate at which blood travels through her body also increases. Blood carries oxygen from the lungs to body cells. Therefore, as blood travels faster through the body, more oxygen can be transported to body cells.

B Incorrect. Insulin is a hormone that promotes a reduction of glucose in the blood. Insulin does not affect the level of oxygen in the blood.

C Incorrect. If the athlete's breathing were to become more shallow, her body would take in less oxygen with each breath.

D Incorrect. The athlete's sweat glands are likely to become more active as she runs. Perspiration helps maintain body temperature during exercise. However, increased perspiration will not help muscle cells meet their increased oxygen demand.

Question 10 (page 36)

A Correct. All of the offspring of this cross will have the phenotype for high yields and rapid maturation (all hhMm). Only the genotypes for yield and maturation rate are needed to answer this question. The genotypes for plant height and kernel color can be ignored.

B Incorrect. A cross of these genotypes will produce a generation in which all the plants will exhibit the phenotype for rapid maturation (all Mm), but none will exhibit the phenotype for high yields (all Hh).

C Incorrect. A cross of these genotypes will produce a generation in which one-fourth of the plants will have the phenotype for high yields and rapid maturation (one-fourth hhMm).

D Incorrect. A cross of these genotypes will produce a generation in which all the plants will exhibit the phenotype for low yields (all Hh), and only half will exhibit the phenotype for rapid maturation (half Mm and half mm).

Question 11 (page 37)

A Correct. In some cases, more than one codon can code for the same amino acid. It is possible for a mutation to occur in DNA and for the new codon to still code for the same amino acid. In such a case, the protein that results from the mutated DNA will be identical to the protein that results from normal DNA.

B Incorrect. If the codon GAG were a stop signal, only part of the hemoglobin protein would be made. This partial protein would probably not be able to function normally.

C Incorrect. There are no codons that are unreadable or skipped over during protein synthesis.

D Incorrect. Each tRNA corresponds to only one codon; it can carry only one type of amino acid.

Question 12 (page 38)

A Incorrect. Histamine is a polar molecule. Because polar molecules are not soluble in lipids, they cannot easily diffuse across the cell membrane. Furthermore, an increase in histamine concentration would likely lead to a worsening of allergy symptoms.

B Correct. An antihistamine, which is chemically similar to histamine, can bind to these receptors without causing the reactions within the cell that lead to the inflammatory response. Histamine, in turn, cannot bind to the receptors that are blocked by antihistamines.

C Incorrect. If the number of histamine receptors on a cell's surface were to increase, there would be more opportunities for histamine to bind to these receptors and trigger an allergic reaction. Therefore, an increase in the production of histamine receptors would likely lead to a worsening of allergy symptoms.

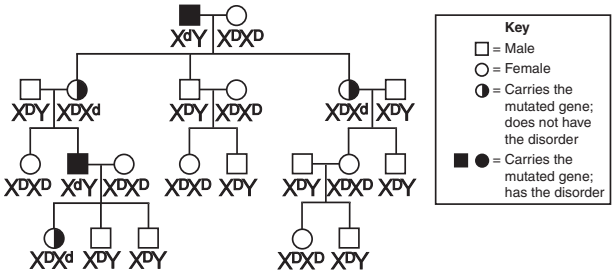
D Incorrect. Histamine is a polar molecule. Because polar molecules are not soluble in lipids, they cannot easily pass through the cell membrane.

Question 13 (page 38)

A Incorrect. If Duchenne muscular dystrophy were an autosomal recessive disorder, then the male in the first generation of the pedigree would have two copies of the mutated gene. All his offspring would be carriers because each would inherit a mutated gene from him. However, one of the offspring of the first generation is not a carrier, so the disorder is not autosomal recessive.

B Incorrect. If Duchenne muscular dystrophy were an autosomal dominant disorder, then anyone who carried at least one copy of the mutated gene would have the disorder. However, two of the females in the second generation and one female in the fourth generation of the pedigree are carriers of the mutated gene but do not have the disorder. So the disorder is not autosomal dominant.

C Correct. The gene is located on the X chromosome. In the pedigree below, X^D represents an X chromosome with a copy of the normal, dominant gene, and X^d represents an X chromosome with a copy of the mutated, recessive gene. Females with one copy of the mutated allele are not affected by the disorder, because they also have an X chromosome with a normal, dominant allele. Males with one copy of the mutated allele, however, will have the disorder because they have only one X chromosome.



D Incorrect. If Duchenne muscular dystrophy were a sex-linked dominant disorder, a daughter would have the disorder if she inherited one copy of the mutated allele. However, the daughters of the first generation in the pedigree have one copy of the mutated allele but do not have the disorder. The disorder is not sex-linked dominant.

Question 14 (page 39)

A Incorrect. Each F_1 parent has a genotype of Bb. Because both F_1 parents are heterozygous, not all the F_2 mice will have BB genotypes, nor will all the F_2 mice be black. See the Punnett square in the explanation for the correct answer.

B Incorrect. Each F_1 parent has a genotype of Bb. Because both F_1 parents are heterozygous, not all the F_2 mice will have bb genotypes, nor will all the F_2 mice be white. See the Punnett square in the explanation for the correct answer.

C Correct. The F_1 generation has a genotype of Bb. Each mouse inherits a B allele from its BB parent and a b allele from its bb parent. The B allele is dominant because a mouse with a genotype of Bb has a black coat. The F_2 generation is the result of a heterozygous cross (Bb × Bb). The expected genotypes are 25% BB, 50% Bb, and 25% bb. Because both BB and Bb mice have black coats, the expected phenotypes are 75% black coats and 25% white coats.

Heterozygous Black (Bb)

Heterozygous Black (Bb)	B	b
B	BB Black	Bb Black
b	Bb Black	bb White

D Incorrect. Each F_1 parent has a genotype of Bb. It is possible for an F_2 mouse to inherit a B allele from one parent and a b allele from the other. These mice would NOT have BB or bb genotypes. In addition, the Punnett square in the explanation for the correct answer shows that there will be more black F_2 mice than white F_2 mice.

Objective 3

Question 15 (page 46)

A Correct. The two-tone color of the shell is most likely a form of camouflage that makes detection by predatory birds and fish difficult. To get this question correct, it is not important to know everything (or anything) about common purple snails. But it is very important to read the question carefully and understand the basic concept of natural selection.

B Incorrect. The common purple snail is unable to swim and relies on random encounters with prey organisms. Shell color plays no role in feeding or in competition with other organisms.

C Incorrect. Shell color is not an adaptation to average water temperature.

D Incorrect. Shell color offers no selective advantage for locating prey or increasing the number of encounters with prey organisms.

Question 16 (page 46)

A Incorrect. There is no evidence that the bacteria in yogurt prevent or stop viral reproduction.

B Incorrect. The bacteria in yogurt do not eat other bacteria.

C Correct. Antibiotics cannot tell the difference between helpful and harmful bacteria. This means that most antibiotics will act upon many types of bacteria in the human body, including bacteria in the digestive tract needed for good health.

D Incorrect. Dietary fiber is the part of a plant's tissue that cannot be digested by humans. Yogurt is made from milk, not plants, so it does not contain dietary fiber.

Question 17 (page 47)

A Incorrect. Jawed fishes descended from primitive jawless fishes. The diagram does not show the evolutionary history of jawless fishes. Therefore, it is not possible to know whether they are extinct.

B Incorrect. According to the diagram, amphibians evolved from lobe-finned fishes but not directly from lungfish.

C Correct. All ray-finned and lobe-finned fishes have bony skeletons. The diagram shows that ray-finned and lobe-finned fishes evolved from an older type of bony fish.

D Incorrect. According to the diagram, sturgeon and coelacanths both evolved from a common ancestor, the bony fishes. Sharks evolved from cartilaginous fishes.

Question 18 (page 48)

A Correct. When this evergreen cone opens, it releases small seeds with papery "wings." The lightweight seeds are carried on wind currents and are deposited some distance from the parent plant.

B Incorrect. These berries may be eaten by a bird or mammal. The seeds in the berries will pass unharmed through the animal's digestive tract. They are then deposited at a location some distance from the parent plant.

C Incorrect. Seeds such as this cocklebur catch in the fur of animals or on clothing and are carried some distance from the parent plant.

D Incorrect. Coconuts may germinate on the beach close to their parent trees, or ocean currents may carry them to a different location.

Question 19 (page 48)

A Incorrect. Thick soil forms in tropical rain forests because warmth and moisture cause intense chemical weathering and the rapid decay of organic matter. The shallow roots of rain-forest plants have little effect on these processes.

B Incorrect. The vegetation in a tropical rain forest does limit erosion. However, the lack of significant erosion does not cause nutrients to build up in the soil. Rather, nutrients are quickly removed by plants.

C Correct. Organic matter on the forest floor is rapidly decomposed and recycled because of the warm, moist conditions and the presence of numerous decomposers. Nutrients are quickly removed by plants, so most nutrients are stored in the biomass of the organisms that live in the rain forest.

D Incorrect. The vegetation in a tropical rain forest may moderate daily temperature variations, but the high temperatures throughout the year are due to the location near the equator.

Question 20 (page 49)

A Correct. A secondary consumer feeds on primary consumers. A tertiary consumer feeds on secondary consumers. Notice how the hawk and the snake fill these different roles in these food chains.

Wood rat (primary consumer) → snake (secondary consumer)

Termite (primary consumer) → lizard (secondary consumer) → snake (tertiary consumer)

Wood rat (primary consumer) → hawk (secondary consumer)

Termite (primary consumer) → lizard (secondary consumer) → hawk (tertiary consumer)

B Incorrect. The lizard feeds on primary consumers, so it is a secondary consumer in this food web. The wood rat does not feed on any primary consumers, so it is not a secondary consumer.

C Incorrect. The hawk is both a secondary and a tertiary consumer in this food web. However, the termite does not feed on any primary consumers, so it is not a secondary consumer.

D Incorrect. The snake is both a secondary and a tertiary consumer in this food web. According to the food web, the lizard feeds on two primary consumers, the moth and the termite, but no secondary consumers.

Question 21 (page 49)

A Incorrect. Although mosquitoes can transmit diseases such as malaria and yellow fever, they play no role in the transmission of tuberculosis. The lungs are the usual site of such an infection.

B Incorrect. It may be possible to spread tuberculosis bacteria through a blood transfusion, but it is unlikely. These bacteria most often reside in the lungs, and blood donors are carefully screened.

C Correct. Tuberculosis is spread from person to person through the air. The lungs are the usual site of this disease. When a person with active tuberculosis coughs, sneezes, or speaks, droplets containing the bacteria are expelled from the lungs. If another person inhales these airborne droplets, that person can become infected with tuberculosis. To get this question correct, it is not important to know everything (or anything) about tuberculosis. But it is very important to read the question carefully and understand that diseases of the lungs will most likely be transmitted through the air.

D Incorrect. The bacteria that cause tuberculosis are not transmitted by contaminated water. They reside only in living hosts. The lungs are the usual site of a tuberculosis infection.

Objective 4

Question 22 (page 63)

Find the formula for density in the formula chart on page 8:

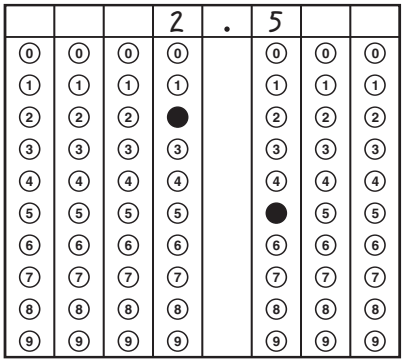
$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

The mass of the liquid is equal to the reading on the scale minus the mass of the empty cylinder:

$$201.76\text{ g} - 87.76\text{ g} = 114\text{ g}$$

The volume of liquid can be determined from the picture of the graduated cylinder. The volume is 45 mL. Now use the formula:

$$\text{Density of the liquid} = \frac{114\text{ g}}{45\text{ mL}} = 2.5\text{ g/mL}$$



If you add a zero after the 5 or before the 2, the answer would still be correct.

Question 23 (page 63)

A Incorrect. The density of steel is greater than the density of seawater. However, this fact does not explain why a ship with a steel hull is able to float.

B Incorrect. The buoyant force on the ship is equal to the weight of the seawater displaced by the ship. If the weight of seawater displaced by the ship were less than the weight of the ship itself, the ship would sink, not float.

C Correct. The ship has a hollow steel hull, which means that most of the volume of the ship is taken up by air. Because air is much less dense than seawater, the density of the ship as a whole (hull plus air) is less than the density of seawater. Therefore, the volume of seawater that the ship displaces weighs more than the ship, and the ship floats.

D Incorrect. The buoyant force on an object is always equal to the weight of the liquid displaced by the object. Whether the object sinks or floats depends on the weight of the object compared to the weight of the liquid it displaces.

Question 24 (page 63)

A Incorrect. Sodium bicarbonate ($NaHCO_3$) has a lower molecular mass than sodium carbonate (Na_2CO_3) does. Even if sodium bicarbonate did have a greater mass, that would not account for the difference in mass between the reactant and the solid product.

B Correct. According to the law of conservation of mass, the mass of the reactants in a chemical reaction is equal to the mass of the products. Because the mass of the product sodium carbonate does not equal the mass of the reactant sodium bicarbonate, there must be other products. These products are most likely gases because sodium carbonate is the only solid product of the reaction. The chemical reaction is:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

The mass of sodium carbonate plus the mass of the carbon dioxide plus the mass of the water is equal to the mass of sodium bicarbonate.

C Incorrect. The law of conservation of mass states that matter is not destroyed during a chemical reaction. All the atoms that are present in the reactants of a chemical reaction will also appear in the products.

D Incorrect. The law of conservation of mass states that the total mass of the reactants in a chemical reaction is equal to the total mass of the products.

Question 25 (page 64)

B Correct. The graph shows that the solubility of KNO_3 decreases as the temperature decreases. At 60°C a saturated solution can hold about 95 grams of KNO_3 per 100 grams of water. At 25°C a saturated solution can hold only about 30 grams of KNO_3 per 100 grams of water. To find the mass of KNO_3 that settles out of the solution, find the difference between the solubilities:

$$95\text{ g} - 30\text{ g} = 65\text{ g}$$

So about 65 grams of KNO_3 will have settled out of the solution once it has cooled.

Question 26 (page 64)

A Correct. The sugar added to this beaker is composed of small granules, so it has a large total surface area. The greater the surface area of the particles, the faster they will dissolve. In addition, the solution is being stirred with a stirring rod. Stirring brings more water in contact with the surface of the sugar, which increases the dissolving rate. Finally, the water in this beaker is hot. For solid solutes such as sugar, increasing the temperature increases the rate at which the solute dissolves.

B Incorrect. The water in this beaker is below room temperature. Because of the lower temperature, the sugar added to this beaker will tend to dissolve more slowly than sugar added to warmer water. In addition, the sugar is in large cubes rather than small granules, which decreases the surface area. The sugar added to this beaker will tend to dissolve more slowly than sugar with a smaller particle size.

C Incorrect. The sugar added to this beaker is in large cubes rather than small granules, which decreases the surface area. So the sugar cubes will tend to dissolve more slowly than sugar with a smaller particle size. In addition, the solution is not being stirred with a stirring rod. As a result, the sugar will dissolve more slowly than sugar added to water that is stirred.

D Incorrect. The water in this beaker is below room temperature. Because of the lower temperature, the sugar will tend to dissolve more slowly than sugar added to warmer water. In addition, the solution is not being stirred with a stirring rod. As a result, the sugar will dissolve more slowly than sugar added to water that is stirred.

Question 27 (page 65)

A Correct. The solubility of a gas in water decreases as the temperature increases. As thermal pollution causes the temperature of the lake to rise, the amount of oxygen dissolved in the lake will decrease. Fish need dissolved oxygen in order to survive, so they may be negatively affected by such a change. To get this question correct, it is important to read the question carefully and to understand how temperature affects the solubility of a gas.

B Incorrect. The solubility of a gas in water decreases as the temperature increases. As the temperature of the lake rises, the solubility of carbon dioxide gas will decrease.

C Incorrect. Potassium chloride (KCl) is a solid. In general, the solubility of solids in water increases with temperature. Therefore, KCl and other potassium fertilizers will become more soluble in the lake as the amount of thermal pollution increases.

D Incorrect. Quartz crystals are solids. In general, the solubility of solids in water increases with temperature. However, most minerals have a low solubility in water. For instance, quartz has a solubility of less than 10 parts per million. As a lake's temperature rises, the increase in the solubility of minerals would not significantly increase and harm fish.

Question 28 (page 65)

D Correct. According to the law of conservation of mass, each side of a balanced equation must have the same number of atoms of each element. So the balanced equation is:

$$2Al(s) + 3CuSO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3Cu(s)$$

Each side of the equation has 2 aluminum atoms (Al), 3 copper atoms (Cu), 3 sulfur atoms (S), and 12 oxygen atoms (O).

Objective 5

Question 29 (page 81)

C Correct. When the epicenter is 4,000 kilometers from the seismograph, it takes 7 minutes for the P wave to arrive and 12 minutes 30 seconds for the S wave to arrive. The S wave arrives 5 minutes 30 seconds after the P wave:

$$12 \text{ min } 30 \text{ s} - 7 \text{ min} = 5 \text{ min } 30 \text{ s}$$

If the P wave arrives at 05:26:00, then the S wave arrives at 5:31:30 because:

$$05:26:00 + 00:05:30 = 05:31:30$$

Question 30 (page 81)

B Correct. From the information given, we know:

time = 4 s

Force = 1500 N

distance = 1.5 m

We need to calculate the power.

The two formulas we need to use are:

$P = \frac{W}{t}$ and $W = Fd$

Substitute these values into the work formula:

Work = 1500 N × 1.5 m

1500 N × 1.5 m = 2250 Nm

2250 Nm = 2250 J

Now use the power formula:

$\text{Power} = \frac{\text{work}}{\text{time}}$

$\frac{2250 \text{ J}}{4.0 \text{ s}} = 562.5 \text{ J/s}$

562.5 J/s = 562.5 W

562.5 W ≈ 563 W

So, the weight lifter uses about 563 watts of power.

Question 31 (page 82)

D Correct. Because the four-door family car has the greatest mass, it would strike the wall with the greatest force.

Question 32 (page 82)

A Incorrect. Although Bulbs 2 and 3 are wired in parallel, their branches are wired in series with Bulb 1. If electric current cannot pass through Bulb 1, the circuit will be broken and none of the bulbs will remain lit.

B Incorrect. In this circuit the three bulbs are wired in series. As a result, the circuit will be broken and none of the bulbs will remain lit if Bulb 1 burns out.

C Correct. In this series Bulbs 1 and 3 are wired in parallel, and their branches are wired in series with Bulb 2. If Bulb 1 burns out, there will still be a complete circuit that includes the battery, Bulb 2, and Bulb 3. Therefore, Bulbs 2 and 3 will remain lit even though Bulb 1 burns out.

D Incorrect. Although Bulbs 1 and 3 are wired in parallel with Bulb 2, they are wired in series with each other. As a result, electric current will not pass through Bulb 3 if it cannot pass through Bulb 1. Bulb 2, however, will remain lit even if Bulb 1 burns out; there will still be a complete circuit that includes the battery and Bulb 2.

Question 33 (page 83)

A Incorrect. The amplitude of the waves would increase only if the waves were carrying more energy. The energy of the waves is determined by the source—the siren. Because the source does not change, the amplitude of the waves remains constant.

B Incorrect. The wavelength of the waves decreases in front of the moving ambulance.

C Incorrect. The speed of a sound wave depends only on the medium it travels through, not on the motion of the source. The speed of these sound waves remains constant.

D Correct. As the ambulance moves toward the man, each sound wave is produced at a point closer to him. As a result, the wave crests in front of the moving ambulance are closer together than if the ambulance were not moving. Therefore, the wavelength of the waves is shorter in front of the moving ambulance. Because the wave crests are closer together, more of them reach the man in a given unit of time. Therefore, the frequency increases, and the sound that he hears is a higher pitch.

Question 34 (page 83)

D Correct. To solve this problem, use the formula for acceleration in the formula chart on page 8:

$$\text{Acceleration} = \frac{\text{final velocity} - \text{initial velocity}}{\text{change in time}}$$

Since the stone is dropped, the acceleration of the stone due to gravity is 9.8 m/s². This constant is listed in the constants/conversions chart. The initial velocity of the stone is 0 m/s. The change in time is 2.30 seconds. Substitute these values into the formula and solve for the final velocity of the stone.

$$a = \frac{v_f - v_i}{\Delta t}$$

$$9.8 \text{ m/s}^2 = \frac{v_f - 0 \text{ m/s}}{2.30 \text{ s}}$$

$$9.8 \text{ m/s}^2 = \frac{v_f}{2.30 \text{ s}}$$

$$9.8 \text{ m/s}^2(2.30 \text{ s}) = v_f$$

$$22.54 \text{ m/s} = v_f$$

The velocity of the stone when it hits the river is 22.54 m/s ≈ 22.5 m/s.

Question 35 (page 83)

A Incorrect. Even though the crate is moved farther than the other objects, its movement does not involve the greatest amount of work. The work done to move the crate is calculated by the formula: Work = force × distance or 10 N × 9.8 m = 98 J.

B Correct. Look at the formula chart on page 8 to find the formula for work:

Work = force × distance.

The force used to move the wagon is 50 newtons, and the wagon is moved a distance of 5.2 meters. Substitute these values into the formula.

Work = force × distance or 50 N × 5.2 m = 260 J.

C Incorrect. Even though a greater force is used to move the sled than either the crate or the wagon, its movement does not involve the greatest amount of work. The work done to move the sled is calculated by the formula:

Work = force × distance or 90 N × 2.3 m = 207 J.

D Incorrect. Work is accomplished only when the force applied to an object results in the movement of the object. Because the car does not move, no work is done: 150 N × 0 m = 0 J.

Cluster 1

Question 36 (page 85)

A Incorrect. According to the food web, beetles feed on snails, slugs, and springtails, and springtails feed on dead organic matter, bacteria, fungi, and nematodes. There is no indication that spiders eat the same food as beetles and springtails.

B Incorrect. None of the information given indicates that the space available has changed.

C Correct. When the spider population increased after the removal of the centipedes, there were more spiders to prey on beetles and springtails. As a result, the populations of these insects decreased.

D Incorrect. Herbivores feed on plants. The beetles and springtails in this food web do not feed on plants (although one food source for springtails is dead plant material). Therefore, the beetles and springtails in the compost pile are unlikely to compete with herbivores for food.

Question 37 (page 85)

A Incorrect. To answer this question, the students would need to make measurements of the moisture content of both compost piles at regular time intervals.

B Incorrect. To answer this question, the students would need to use different types of organic material in the two compost piles.

C Correct. The variable that the students change is the amount of water the compost piles receive. They can determine in which pile more organisms live (the moist one or the dry one) by random sampling of the number of different types of organisms in each pile.

D Incorrect. To answer this question, the students would need to either add carnivores to one of the piles or remove carnivores from one of the piles.

Question 38 (page 85)

A Incorrect. The cells of fungi do not contain chloroplasts. Fungi do not make their own food from sunlight. Instead, fungi obtain food by absorbing it into their cells. Many fungi feed on the remains of dead organisms.

B Incorrect. The cells of bacteria lack most types of organelles, including chloroplasts.

C Incorrect. Sow bugs are animals. Animal cells do not contain chloroplasts. Animals cannot make their own food by using the energy from sunlight.

D Correct. Grasses are plants. Plants make their own food by using the energy from sunlight. This process takes place in the chloroplasts of plant cells.

Question 39 (page 85)

C Correct. Find the formula for work in the formula chart on page 8: work = force × distance ($W = Fd$). The distance the bag moves is 0.5 meter. The minimum amount of force needed to lift the bag is equal to the force of gravity on the bag.

The formula for force given in the formula chart is: Force = mass × acceleration ($F = ma$). The mass of the bag is 36 kilograms, and the acceleration due to gravity given in the constants/conversions chart on page 8 is 9.8 m/s^2. Substitute these values into the force formula:

$$\text{Force} = \text{mass} \times \text{acceleration}$$
$$F = ma$$
$$F = 36 \text{ kg} \times 9.8 \text{ m/s}^2$$
$$F = 352.8 \text{ kgm/s}^2$$
$$F = 352.8 \text{ N}$$

Now use the work formula:

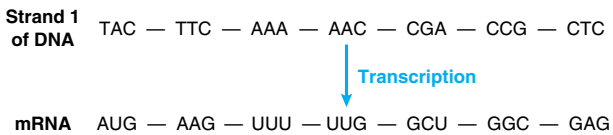
$$\text{Work} = \text{force} \times \text{distance}$$
$$W = Fd$$
$$W = 352.8 \text{ N} \times 0.5 \text{ m}$$
$$W = 176.4 \text{ Nm}$$
$$W = 176.4 \text{ J}$$

The gardener needs to do at least 176.4 joules of work to lift the bag to a height of 0.5 meter.

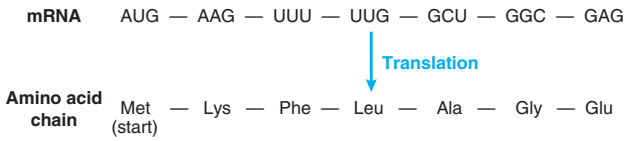
Cluster 2

Question 40 (page 87)

B Correct. First Strand 1 of the DNA section is transcribed to mRNA. The mRNA has the same sequence of bases as Strand 2 of the DNA section, except that the base uracil (U) is substituted for thymine (T).



Then the mRNA strand is translated to produce an amino acid chain. Use the codon chart to determine which amino acid matches each mRNA codon.



The amino acid chain that results is Met—Lys—Phe—Leu—Ala—Gly—Glu

Question 41 (page 87)

A Incorrect. This mutation is one that is beneficial to the plant. Therefore, the mutation makes it more likely that the plant will live long enough to pass on its genes to offspring.

B Incorrect. There is no evidence to suggest that the species of bacteria needs the plant species in order to survive. Even if resistance to the bacteria spreads throughout the plant species, there may be other types of organisms that the bacteria could use as hosts or food sources.

C Correct. This mutation is beneficial to the plant. Therefore, this change is likely to be passed on to offspring. Because the offspring would be resistant to the harmful bacteria, they would be more likely to survive and pass on the mutation to a third generation. Eventually the number of resistant plants could be quite large.

D Incorrect. This mutation makes the plant resistant to the harmful bacteria. If this mutation is passed on through many generations of plants, it will be more likely to have a negative effect on the bacteria than a positive effect.

Question 42 (page 87)

A Incorrect. The amino acids listed in the table become more soluble as the temperature increases.

B Incorrect. At 50°C, leucine is less soluble in water than aspartic acid is.

C Incorrect. As the temperature increases from 0°C to 50°C, the solubility of aspartic acid increases more than the solubility of serine. So, temperature has a greater effect on the solubility of aspartic acid than on the solubility of serine.

D Correct. Each of the amino acids listed in the table becomes more soluble in water as the temperature of the water increases from 0°C to 25°C to 50°C.

Science Activity

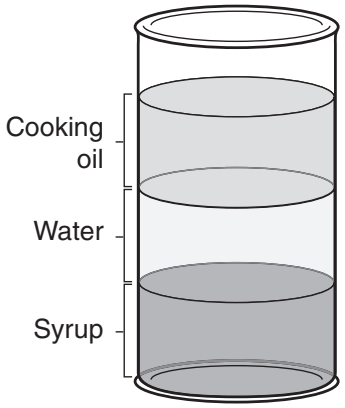
Liquid Rainbow (page 88)

Did the oil mix with the water, or did it stay in a separate layer? If the oil stayed in its own layer, did it sink or float on water? The oil stayed in a separate layer that floated on top of the water.

Describe what happened when you added the syrup to the glass. The syrup stayed in its own layer and sank to the bottom of the glass.

Floating Layers (page 89)

The sketch of your density column will depend on the types of objects you add to it. A sample sketch is shown below.



Did the liquids mix together? Why or why not? No. The liquids didn't mix together, because they are not very soluble in one another at room temperature and because they have different densities.

What determines the order of the liquid layers in the glass? The density of the liquids determines their order. The densest liquid is on the bottom of the glass, and the least-dense liquid is on the top.

List the liquids in order from least dense to most dense. The correct order is: cooking oil, water, syrup.

Seeing Is Believing (page 90)

Liquid	Mass (g)	Volume (mL)	Density
Water	30.0	30.0	1.00 g/mL
Cooking oil	27.6	30.0	0.92 g/mL
Syrup	41.4	30.0	1.38 g/mL

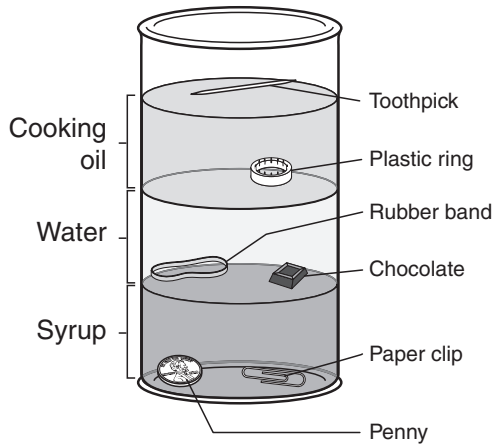
Based on your calculations, list the liquids in the table in order from least dense to most dense. The correct order is: cooking oil, water, syrup.

Does this list agree with what you observed in your density column? Explain. Yes. My calculations and my density column both show that cooking oil is less dense than water and that syrup is denser than water.

Gather Some Solid Evidence (page 91)

What happens when you drop the rubber band into your density column? What does the position of the rubber band tell you about its density? The rubber band floats at the boundary between the syrup and the water. The rubber band is denser than water but less dense than syrup.

List the solids and liquids in your density column in order from least dense to most dense. Your answer will depend on the solids you used. Sample: toothpick, cooking oil, plastic ring, water, chocolate, rubber band, syrup, paper clip, penny



A Legendary Mystery (page 92)

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$D = \frac{m}{v}$$

$$D = \frac{4.18\ \text{g}}{0.23\ \text{cm}^3}$$

$$D = 18.2\ \text{g/cm}^3$$

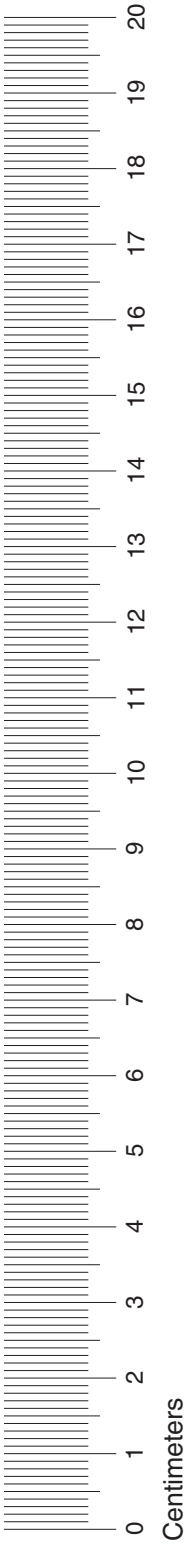
The coin has a density of 18.2 g/cm^3.

Is the coin found by the archaeologist made of pure gold? Explain. No. The density of the coin (18.2 g/cm^3) is less than the density of pure gold (19.3 g/cm^3).

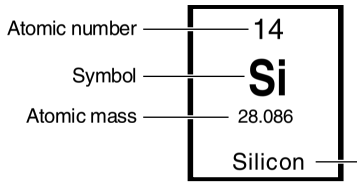
FORMULA CHART
for Grades 10–11 Science Assessment

Density $=\frac{\text{mass}}{\text{volume}}$	$D=\frac{m}{v}$
$\begin{pmatrix}\text{heat gained or}\\ \text{lost by water}\end{pmatrix}=\begin{pmatrix}\text{mass}\end{pmatrix}\begin{pmatrix}\text{change in}\\ \text{temperature}\end{pmatrix}\begin{pmatrix}\text{specific}\\ \text{heat}\end{pmatrix}$	$Q=(m)(\Delta T)(C_p)$
Speed $=\frac{\text{distance}}{\text{time}}$	$v=\frac{d}{t}$
Acceleration $=\frac{\text{final velocity} - \text{initial velocity}}{\text{change in time}}$	$a=\frac{v_f - v_i}{\Delta t}$
Momentum = mass × velocity	$p=mv$
Force = mass × acceleration	$F=ma$
Work = force × distance	$W=Fd$
Power $=\frac{\text{work}}{\text{time}}$	$P=\frac{W}{t}$
% efficiency $=\frac{\text{work output}}{\text{work input}}\times 100$	$\%=\frac{W_O}{W_I}\times 100$
Kinetic energy $=\frac{1}{2}$(mass × velocity^2)	$KE=\frac{mv^2}{2}$
Gravitational potential energy = mass × acceleration due to gravity × height	$GPE=mgh$
Energy = mass × (speed of light)^2	$E=mc^2$
Velocity of a wave = frequency × wavelength	$v=f\lambda$
Current $=\frac{\text{voltage}}{\text{resistance}}$	$I=\frac{V}{R}$
Electrical power = voltage × current	$P=VI$
Electrical energy = power × time	$E=Pt$

Constants/Conversions		
g = acceleration due to gravity = 9.8 m/s^2		
c = speed of light = 3×10^8 m/s		
speed of sound = 343 m/s at 20°C		
1 cm^3 = 1 mL		
1 wave/second = 1 hertz (Hz)		
1 calorie (cal) = 4.18 joules		
1000 calories (cal) = 1 Calorie (Cal) = 1 kilocalorie (kcal)		
newton (N) = kgm/s^2		
joule (J) = Nm		
watt (W) = J/s = Nm/s		
volt (V)	ampere (A)	ohm (Ω)



Periodic Table of the Elements



Group	1 IA		3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.008 Hydrogen	2 IIA																2 He 4.0026 Helium
2	3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.179 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminum	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.066 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.08 Calcium	21 Sc 44.956 Scandium	22 Ti 47.88 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.847 Iron	27 Co 58.933 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc (98) Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.906 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.868 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.763 Antimony	52 Te 127.60 Tellurium	53 I 126.904 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.905 Cesium	56 Ba 137.33 Barium	57 La 138.906 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.383 Thallium	82 Pb 207.2 Lead	83 Bi 208.980 Bismuth	84 Po (209) Polonium	85 At (210) Astatine	86 Rn (222) Radon
7	87 Fr (223) Francium	88 Ra 226.025 Radium	89 Ac 227.028 Actinium	104 Rf (261) Rutherfordium	105 Db (262) Dubnium	106 Sg (263) Seaborgium	107 Bh (262) Bohrium	108 Hs (265) Hassium	109 Mt (266) Meitnerium	110 (269)								

Mass numbers in parentheses are those of the most stable or most common isotope.

Lanthanide Series	58 Ce 140.12 Cerium	59 Pr 140.908 Praseodymium	60 Nd 144.24 Neodymium	61 Pm (145) Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.925 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.930 Holmium	68 Er 167.26 Erbium	69 Tm 168.934 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium
Actinide Series	90 Th 232.038 Thorium	91 Pa 231.036 Protactinium	92 U 238.029 Uranium	93 Np 237.048 Neptunium	94 Pu (244) Plutonium	95 Am (243) Americium	96 Cm (247) Curium	97 Bk (247) Berkelium	98 Cf (251) Californium	99 Es (252) Einsteinium	100 Fm (257) Fermium	101 Md (258) Mendelevium	102 No (259) Nobelium	103 Lr (262) Lawrencium

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